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TECHNICAL MEMORANDUM

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CIVIL ENGINEERING LABORATORY
NAVAL CONSTRUCTION BATTALION CENTER
Port Hueneme, California 93043

AIRFIELD PAVEMENT CONDITION SURVEY, USNAS MIRAMAR, CALIFORNIA

Technical Memorandum M-75-53-2

53-024

by

R. B. Brownie

ABSTRACT

The results of a condition survey and friction measurements on the runways at the U.S. Naval Air Station, Miramar, California are presented. The survey established statistically-based condition numbers (weighted defect densities) which were direct indicators of the condition of the individual pavement facilities. The runway friction measurements showed the aircraft hydroplaning/skidding potential of the field. The results of the condition survey show an increasing amount of joint seal defects. Continuing repairs have effected a decrease in the number of spalls. Runway friction measurements show that all runways have satisfactory frictional resistance.

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INTRODUCTION

In October 1969, the Naval Facilities Engineering Command authorized a series of periodic pavement condition surveys to be conducted at Naval and Marine Corps Air Stations. The purpose of these conditions surveys was to determine the suitability of the airfield pavement surfaces for aircraft operations, and to establish a uniform basis for maintenance and repair efforts. A pavement condition survey was conducted at the Naval Air Station, Miramar, California by the Naval Civil Engineering Laboratory* in January 1970 and reported in reference (1). Commencing in FY-75, pavement condition surveys will be performed only on active runways, and increased emphasis will be placed on determining runway friction coefficients. During the month of November 1974, a second pavement condition survey was made at NAS Miramar by CEL. The survey consisted of a sophisticated, statistically-based procedure of pavement defect measurement which permitted the establishment of condition numbers (weighted defect densities) which are direct indicators of the condition of airfield pavement facilities. In June 1975, runway friction measurements were made using a Mu-Meter, a small friction-measuring trailer. Additional survey efforts included photographic coverage of pavement defect types, preparation of a construction history of the airfield, compilation of current aircraft traffic data, summarization of climatological data, and delineation of requirements for future pavement evaluation efforts at the station.

BACKGROUND

The U.S. Naval Air Station, Miramar, is located in San Diego County, in the city of San Diego, California, at an elevation of 477 feet. An aerial photograph of the station is shown in Figure 1. The airfield has two major runways and one auxiliary runway. The two major runways, 6R-24L and 6L-24R, are 8,000 feet and 12,000 feet long, respectively, and lie parallel in a generally east-west direction. The auxiliary runway, 10-28, is 6,000 feet long and lies in a northwest-southeast direction.

CONSTRUCTION HISTORY

Original construction of Runways 6L-24R and 10-28 was completed in 1943-44. Runway 6R-24L was completed in 1951. During the ensuing years since original construction, extension and strengthening of the runways and taxiways has been accomplished, along with additions of taxiways and parking aprons. A complete history of construction and recorded maintenance is provided in Appendix A.

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* On 1 January 1974, redesignated the Civil Engineering Laboratory (CEL) of the Naval Construction Battalion Center, Port Hueneme, California

CURRENT AIRCRAFT TRAFFIC

A tabulation of the number of aircraft operations for a 12 month period is shown in Table 1. Table 2 lists the aircraft normally based at the station and transient aircraft observed using the station.

CLIMATOLOGICAL DATA

A summary of climatological data for NAS Miramar is presented in Appendix B.

PAVEMENT CONDITION SURVEY

Condition Survey Procedure

The condition survey procedure used at NAS Miramar was developed by CEL in 1968. This procedure permits the establishment of condition numbers (weighted defect densities) which are direct indicators of the pavement surface condition. A complete description of the pavement condition survey procedure is presented in Appendix C. It should be noted that Appendix C describes procedures for both asphaltic concrete (AC) and portland cement concrete (PCC) pavements, and includes other pavement facilities in addition to runways. At NAS Miramar, only the runways were surveyed. Discrete areas were selected after a preliminary inspection of the runways. The locations of the discrete areas are shown in Figure 2. Defect severity weights as used at NAS Miramar are given in Table 3.

Results of Condition Survey

The results of the survey of each discrete area are shown in the Discrete Area Defect Summary sheets, pages 38 through 45 of this report. Each Discrete Area Defect Summary includes a narrative description of the pavement defects encountered. In addition, photographs of typical pavement conditions noted during the survey can be seen in Figures 3 through 13. Facility Defect Summaries are shown on pages 46 and 47.

Total weighted defect densities for portland cement concrete discrete areas range from 1.30C (0.00C being no visible defects) for discrete area R28-1 to 4.17C for discrete area R24R-2. The only asphaltic concrete discrete area, R24L-3 had a defect density of 0.00A. An analysis of the change in pavement condition since the last condition survey is given in the Discrete Area Condition Analysis sheets, pages 48 through 55 .

RUNWAY FRICTION MEASUREMENTS

The skid resistance/hyrdoplaning characteristics of the runway surfaces were evaluated with a Mu-Meter friction measuring device. The test program consisted of field measurements of skid resistance/ hydroplaning potential under standardized, artificially-wet conditions. In addition, both transverse and longitudinal pavement slopes were measured at intervals along each runway centerline to evaluate surface drainage characteristics.

Test Locations

Test sections on each runway were selected to provide a representative sample of the skid resistance properties of each runway. The test section layout is shown in Figure 14. The test sections were selected to provide pavement friction data in: (a) the aircraft touchdown areas, and (b) the runway interior where maximum braking is normally developed. No friction tests were made on Runway 10-28 as it is used only for arrested landings.

Test Equipment

The principal items of test equipment used were the Mu-Meter, a tank truck for water application, and a device for measuring pavement slopes.

The Mu-Meter is a small trailer, designed and manufactured by M. L. Aviation of Maidenhead, England. It measures the side-force friction coefficient generated between the pavement surface and the pneumatic tires on the two wheels which are set at a fixed toe-out (yaw angle) to the line of drag. The Mu-Meter is a continuous recording device that graphically records the coefficient of friction, mu* versus the distance traveled along the pavement.

The water truck provided by the station was a runway foamer with a spray nozzle and pumping system calibrated to place 0.1 inch of water on the skid test strip with each pass.

The slope measuring device consisted of a rectangular aluminum section (10 feet long, 1 inch thick, and 4 inches high) with machinists levels attached to define slope from 0 to 2.5 percent.

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* The symbol mu or μ designates the coefficient of friction which is a constant used to represent the ratio of frictional force to force normal to the pavement surface.

Test Procedures

The field test procedures utilized at NAS Miramar are those outlined in NAVFAC INSTRUCTION 11132.14B. The methods were:

(1) A preliminary reconnaissance of the pavement surfaces was made and representative test areas (each 1000 or 2000 feet long) were selected for skid testing.

(2) Transverse and longitudinal slope measurements were made at 500 foot intervals along the runway centerline. Transverse measurements were made at two places on each side of the centerline covering a distance of approximately 20 feet. Longitudinal measurements were made on the centerline at the same stations where the transverse measurements were made.

(3) The water truck, which had been calibrated to apply 0.1 inch of water each time it passed over a test strip, made two passes over the test strip.

(4) Mu-Meter runs at 40 miles per hour, 1.2 times the theoretical hydroplaning speed for this vehicle, were initiated immediately after completion of the second water truck pass. Mu-Meter runs were made in alternate directions at convenient time intervals until a dry pavement condition was reached or 30 minutes had elapsed.

(5) All water truck and Mu-Meter operations were measured to the nearest second using a stop watch.

Runway Friction Test Results

The pavement skid resistance results are reported in terms of mu, coefficient of friction, as measured by the Mu-Meter. The actual friction coefficient versus distance traces as recorded by the Mu-Meter during the first run after wetting for each test section are shown in Figures 15 through 20. The traces show the variation of friction coefficient within each test section. Sharp dips in the curves indicate areas of lower friction values. At NAS Miramar the low-coefficient areas correspond to areas of heavy rubber deposits. Appendix D contains all test results for each Mu-Meter test section.

Figures 21 through 24 show changes in surface friction coefficient versus time after wetting for each pavement section tested. (Note that the time intervals after wetting at which skid tests were made often differed from one test to another, due to small variations in water truck speed and Mu-Meter adjustments). These graphs demonstrate the natural drainage characteristics of the runway surface and the time required to return to an essentially dry condition or a consistently high friction coefficient.

A summary of test data and an associated Mu-Meter aircraft pavement rating guide are presented in Tables 4 and 5. The rating guide was developed from the results of an Air Force Weapons Laboratory research program and a joint NASA/AF/FAA test program using actual aircraft correlated with Mu-Meter skid coefficient results. While the current state-of-the-art does not allow a more precise delineation of exact aircraft responses, the rating guide provides a good rule-of-thumb for interpretation of test data.

Table 4 presents the average skid resistance values for each skid test section. From the curves presented in Figures 21 through 24, values of mu were determined for time periods of 3, 15 and 30 minutes after water was applied. The coefficient determined at 3 minutes after water application corresponds to a wet runway condition, and the coefficient determined at 15 minutes after water application corresponds to a damp runway condition. At 30 minutes after wetting, the friction coefficient can be considered a dry pavement condition. The curves in Figures 21 through 24 were extrapolated, if necessary, to obtain friction coefficients at those time intervals. These data indicate the rate the pavement skid resistance properties were recovered after the test sections were wetted. By comparing the actual values of mu shown in Table 4 with the expected aircraft response in the associated rating guide, Table 5, it is possible to evaluate aircraft hydroplaning potential.

Measured pavement slopes are shown in Table 6. Positive transverse slopes indicate water drains to the runway edge without crossing the centerline, while negative transverse slopes indicate drainage crosses the runway centerline before draining to the edge. Positive longitudinal slopes indicate rising pavement grades in the direction of increasing runway stations while negative longitudinal slopes indicate falling grades in the direction of increasing stations.

DISCUSSION OF RESULTS

Condition Survey Results

A decrease in the amount of spalling was noted in all discrete areas since the 1970 condition survey (Reference 1). An increase in the amount of defective joint seal was found in most areas as shown in the Discrete Area Condition Analysis sheets, pages 48 through 55 . No defects were visible in the one asphaltic concrete discrete area due to the seal placed one month before the condition survey.

Runway Friction Measurements

The wet (3 minute) friction coefficients given in Table 4 show that all runways tested have an acceptable level of friction resistance. The only area which demonstrated any potential hydroplaning hazard was the rubber-covered area of Runway 6L-24R as shown in Figure 18. It is also assumed that the FCLP (field carrier landing practice) area on Runway 6R-24L would have similar properties. The FCLP area was not included in the friction test sections as it is located on the side of the runway out of normal aircraft braking areas.

RECOMMENDATIONS FOR FURTHER EVALUATION EFFORT

A comprehensive evaluation was performed at NAS Miramar by NCEL in 1964 (see Reference 2). No defects attributed to changes in load carrying capacity were noted in this current (1974) condition survey. Therefore, no additional evaluation effort is recommended at this time.

REFERENCES

1. U.S. Naval Civil Engineering Laboratory. Technical Note N-1122, Airfield Pavement Condition Survey - USNAS Miramar, California, by D. J. Lambiotte and R. B. Brownie, Port Hueneme, California, August 1970.

2. U.S. Naval Civil Engineering Laboratory, Technical Note N-718: Airfield Pavement Evaluation - USNAS Miramar, California, by R. J. Lowe and W. H. Chamberlin, May 1965.

Table 1. Aircraft Operations Data.
USNAS Miramar, California

Date	Takeoffs and Landings	Touch and Go or Field Mirror Landing Practice
October 1973	8594	2,021
November	5836	3,072
December	4305	3,472
January 1974	5286	6,464
February	5520	6,694
March	6954	6,734
April	7709	10,407
May	6222	7,478
June	5688	6,003
July	6257	7,964
August	6962	5,371
September	5493	5,226
Average per month for the above one year period	6235	5,909

Table 2. Aircraft Using USNAS Miramar, California

Aircraft based at NAS Miramar:	A4, F4, F8, F14, F5, T38, T28, C1
Aircraft using NAS Miramar on a transient basis:	A3, A5, A6, A7, P3, E1, E2, S2, S3, C2, C5, C9, C117, C118, C130, C141, F100, F101, F102, F105, F106, T33, T37, T39, OV10; and 707, 727, 737, DC8, DC9, and numerous other civilian aircraft.

Table 3. Defect Severity Weights

Airifeld: USNAS Miramar, California

Asphaltic Concrete		Portland Cement Concrete	
Defect	Weight	Defect	Weight
Depression	9.0	Depression	9.0
Rutting	9.0	Shattered Slab	9.0
Broken-up Area	9.0	Faulting	8.5
Faulting	8.5	Spalling	7.5
Raveling	7.0	Scaling	7.0
Erosion-Jet Blast	7.5	"D-Line" Cracking	6.5
Longitudinal, Transverse, or Longitudinal Construction Joint Crack	3.0	Pumping	4.0
Pattern Cracking	3.0	Poor Joint Seal	3.0
Patching	3.5	Corner Break	3.0
Reflection Crack	1.5	Intersecting Crack	3.0
Oil Spillage	1.5	Longitudinal or Transverse Crack	1.5

Table 4. Runway Friction Measurement Summary, USNAS Miramar, California

Test Locations	Average Friction Coefficients 3 Min. (Mu)	15 Min. (Mu)	30 Min. (Mu)
Runway 6R-24L			
Test Section A	0.78	0.78	0.78
Test Section B	0.69	0.66	0.64
Test Section C			
AC portion	0.67	0.67	0.63
PCC portion	0.56	0.73	0.75
Runway 6L-24R			
Test Section A	0.47	0.68	0.73
Test Section B	0.65	0.80	0.80
Test Section C	0.57	0.73	0.73
Test Section D	0.69	0.78	0.78

Table 5. Mu-Meter Aircraft Pavement Rating

Mu	Expected Aircraft Braking Response	Hydroplaning Potential
Greater than 0.50	Good	No hydroplaning problems are expected
0.42 - 0.50	Fair	Transitional
0.25 - 0.41	Marginal	Potential for hydroplaning for some aircraft exists under certain wet conditions
Less than 0.25	Unacceptable	Very high probability for most aircraft to hydroplane

Table 6. Runway Slope Measurements, USNAS Miramar, California

Location	Transverse Slopes Left Percent	Transverse Slopes Left Percent	Transverse Slopes Right Percent	Transverse Slopes Right Percent	Longitudinal Slopes Percent
Runway 6R-24L					
0+00	+0.2	+0.1	+0.3	+0.2	-0.4
5+00	+0.4	+0.3	-0.2	-0.3	-0.8
10+00	+0.5	+0.4	+0.7	+1.3	-0.7
15+00	+0.7	+0.4	+0.5	+0.7	-0.7
20+00	+0.5	+0.5	+0.4	+0.5	-0.3
25+00	+0.7	+0.5	+0.7	+0.5	-0.4
30+00	+0.1	-0.1	+0.3	+0.2	-0.5
35+00	+0.3	+0.3	+0.1	+0.2	-0.8
40+00	+0.5	+0.3	+0.7	+0.2	-0.3
45+00	+0.6	+0.4	+0.3	+0.3	-0.3
50+00	+0.3	+0.4	+0.3	+0.3	-0.6
55+00	+0.3	+0.3	+0.5	+0.2	-0.5
60+00	+0.7	+0.2	+0.6	+0.1	-0.5
65+00	+0.2	+0.7	+0.6	+0.4	-0.3
70+00	+0.8	+0.7	+0.4	+0.3	-0.4
75+00	+0.3	+0.3	+0.2	+0.3	-0.3
80+00	+0.3	+0.5	0.0	+0.2	0.0
Runway 6L-24R					
0+00	-0.4	-0.4	+0.4	+0.3	-0.6
5+00	-0.2	-0.5	+0.3	+0.1	-0.6
10+00	0.0	-0.4	+0.3	+0.3	-0.4
15+00	-0.2	-0.2	0.0	-0.2	-0.5
20+00	0.0	+0.2	-0.1	0.0	-0.6
25+00	+0.4	+0.6	+0.2	+0.1	-0.7
30+00	+0.3	+0.7	+0.2	+0.5	-0.4
35+00	-0.1	-0.3	0.0	+0.4	-0.7
40+00	-0.1	0.0	+0.3	0.0	-0.3
45+00	-0.3	-0.8	+0.3	+0.4	-0.2
50+00	+0.3	+0.6	+0.3	+0.1	-0.4
55+00	+0.3	+0.7	+0.3	+0.2	-0.5
60+00	+0.3	+0.2	+0.5	+0.5	-0.7
65+00	+0.7	+0.4	+0.5	+0.3	-0.3
70+00	+0.6	+0.6	+0.4	+0.6	-0.1
75+00	+0.4	-0.1	+0.3	+0.3	-0.4
80+00	+0.7	+0.3	+0.4	+0.4	-0.5
85+00	+0.7	+0.6	+0.7	+0.8	-0.1
90+00	+0.9	+0.8	+1.1	+0.8	-0.1
95+00	+1.1	+0.7	+0.9	+1.0	-0.3
100+00	+1.0	+1.1	+0.8	+0.9	-0.4
105+00	+0.7	+0.6	+0.8	+1.2	0.0
110+00	+1.1	+1.0	+0.8	+1.0	-0.3
115+00	+0.8	+0.7	0.9	+0.8	-0.2
120+00	+0.7	+0.7	-1.1	+0.7	0.0

Table 6. (Con't)

Location	Transverse Slopes				Longitudinal Slopes Percent
	Left		Right		
	Percent	Percent	Percent	Percent	
Runway 10-28					
0+00	+0.7	+0.5	-0.4	-0.2	+0.3
5+00	+0.4	+0.3	-0.2	-0.4	+0.7
10+00	+0.5	+0.5	-0.6	-0.5	+0.6
15+00	+0.5	+0.5	-0.4	-0.6	+0.3
20+00	+0.7	+0.4	-0.5	-0.6	+0.2
25+00	+0.5	+0.6	-0.0	-0.3	+0.3
30+00	+0.7	+0.6	-0.5	-0.6	+0.2
35+00	+0.3	+0.3	-0.7	-0.8	+0.2
40+00	+0.6	+0.5	-0.5	-0.4	+0.1
45+00	+0.4	+0.3	-0.8	-0.3	+0.1
50+00	+0.2	+0.1	-0.6	-0.5	0.1
55+00	0.0	+0.2	-0.6	-0.7	+0.5
60+00	0.0	+0.7	-0.6	-0.1	+0.5

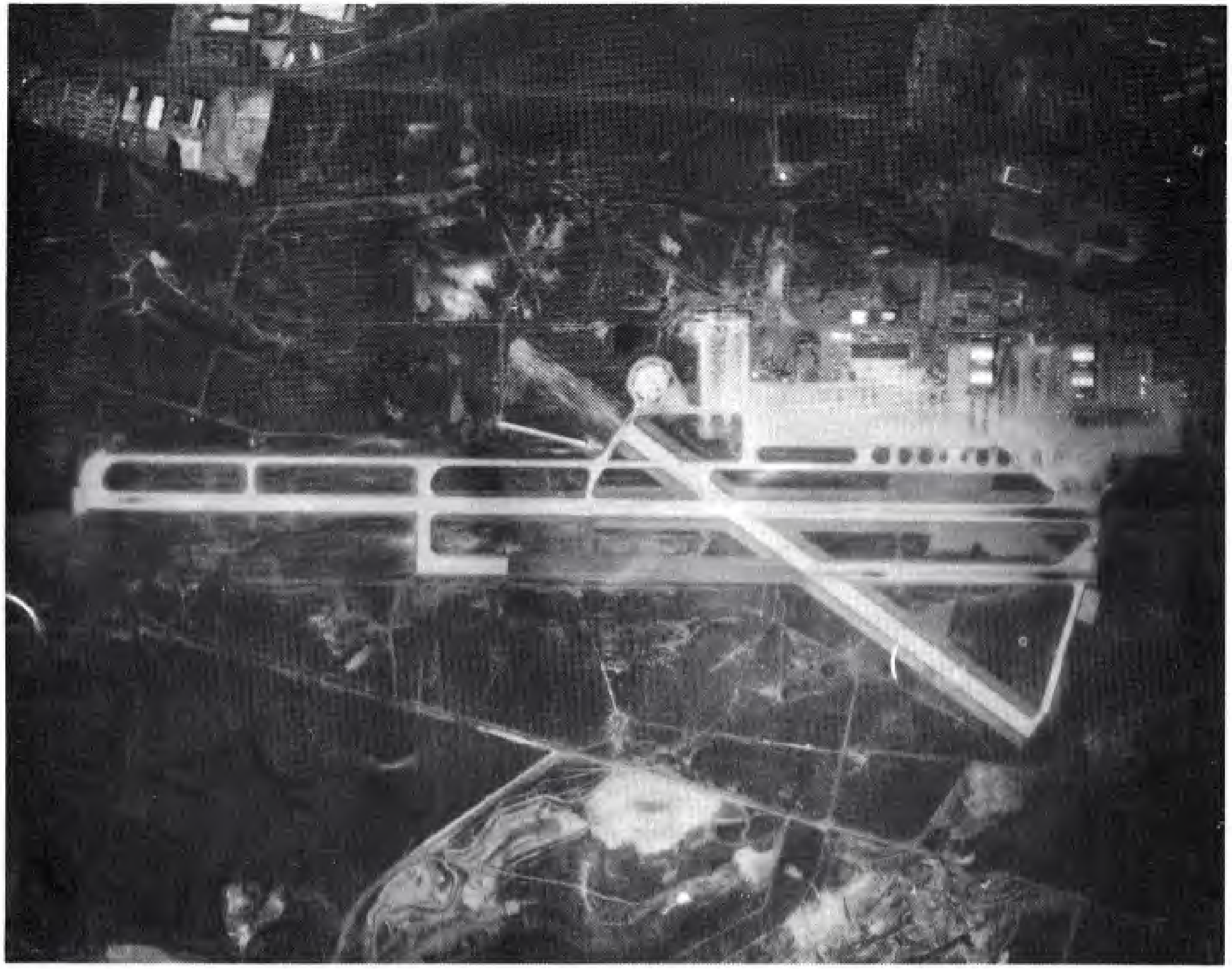


Figure 1. Aerial view of U.S. Naval Air Station, Miramar, California.

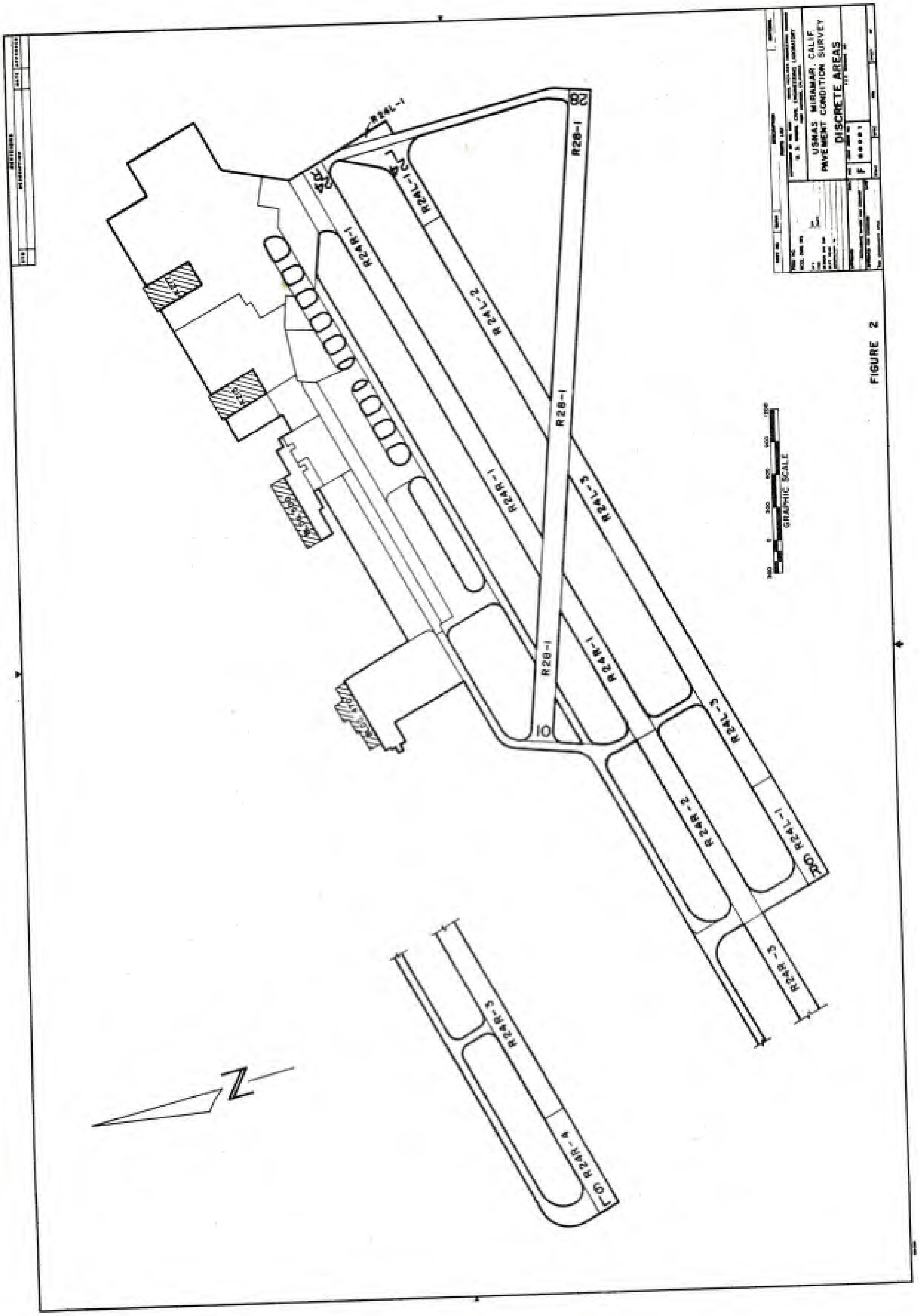

USNAS MIRAMAR, CALIF
PAVEMENT CONDITION SURVEY
DISCRETE AREAS
R24L-1
R24R-1
R24L-2
R24L-3
R28-1
R24R-2
R24R-3
R24R-4
28
10
GRAPHIC SCALE

FIGURE 2

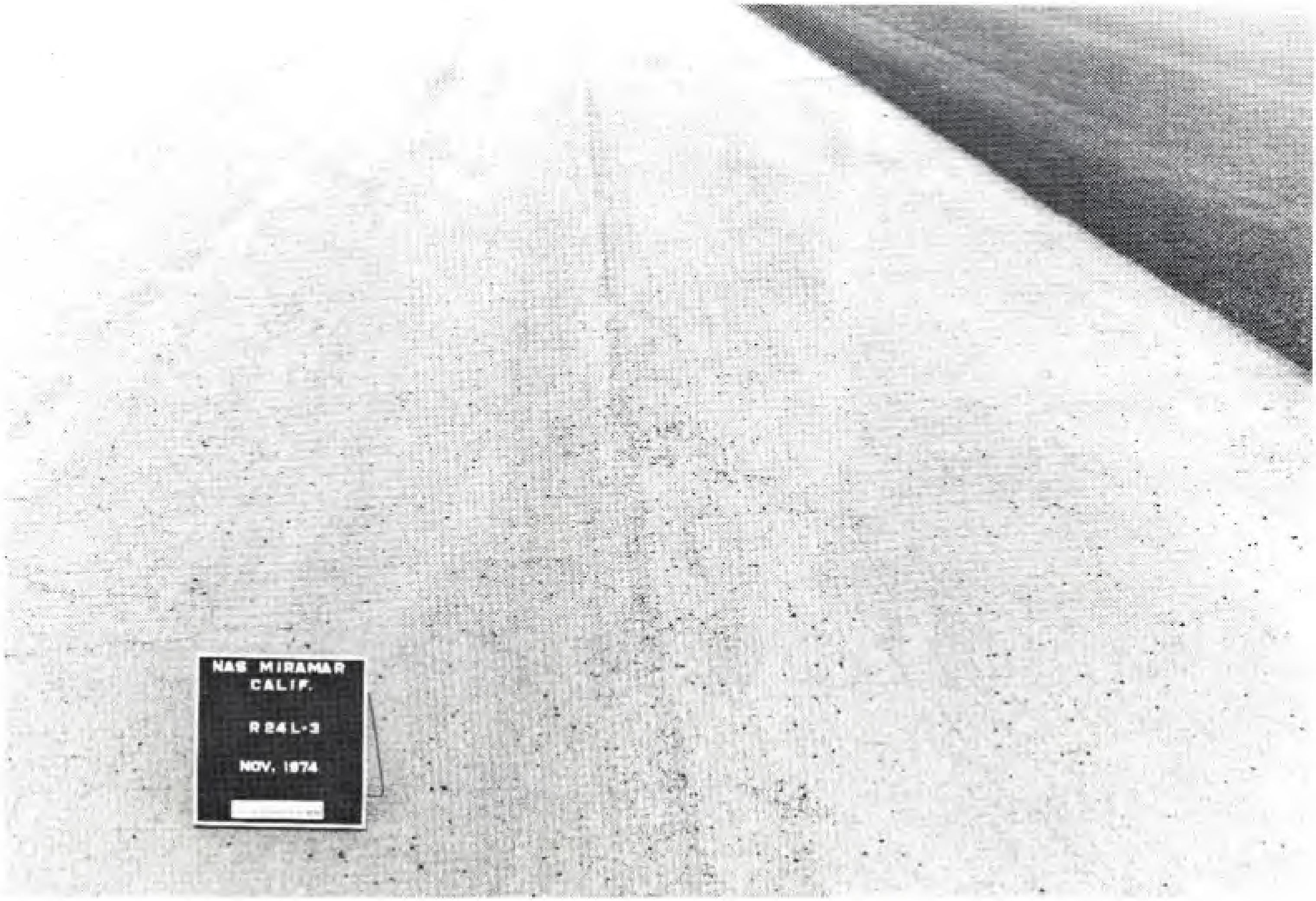


Figure 3. Loose aggregate blown onto runway shoulder from rubber-asphalt seal, Discrete Area R24L-3.

Figure 4. Washboard effect caused by poor chip distribution, Discrete Area R24L-3.

Figure 5. Shriveled and hardened joint seal, Discrete Area R24L-1.

Figure 6. Spall repair with portland cement concrete; note the lack of contraction joint in the repair, Discrete Area R24L-1.

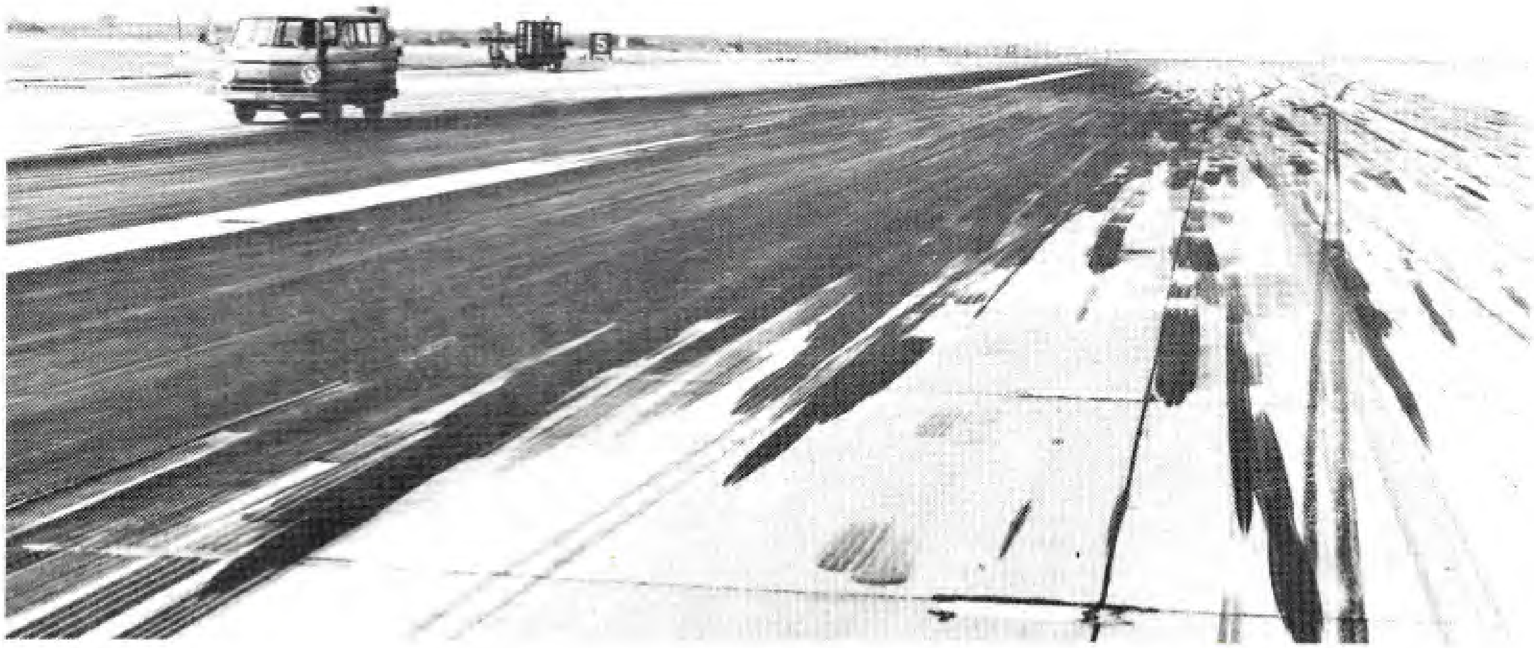


Figure 7. Heavy rubber deposits in the field carrier landing practice area, Discrete Area R24L-2.

Figure 8. Typical spall, Discrete Area R24R-1.

Figure 9. Burned and blown joint seal, Discrete Area R24R-1.

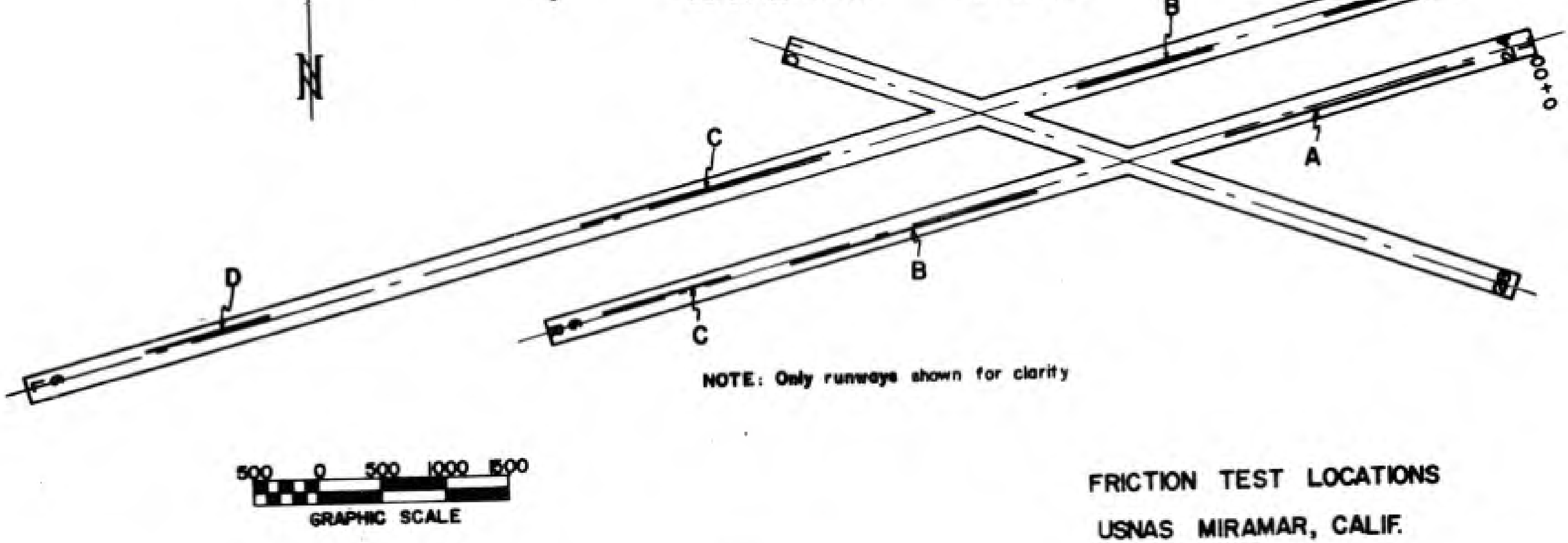
Figure 10. Hardened and shriveled joint seal, Discrete Area R24R-2.

Figure 11. Typical corner spall, Discrete Area R24R-3.

Figure 12. Hardened and shriveled joint seal, Discrete Area R24R-4.

Figure 13. Vegetation growing in joint, Discrete Area R28-1.

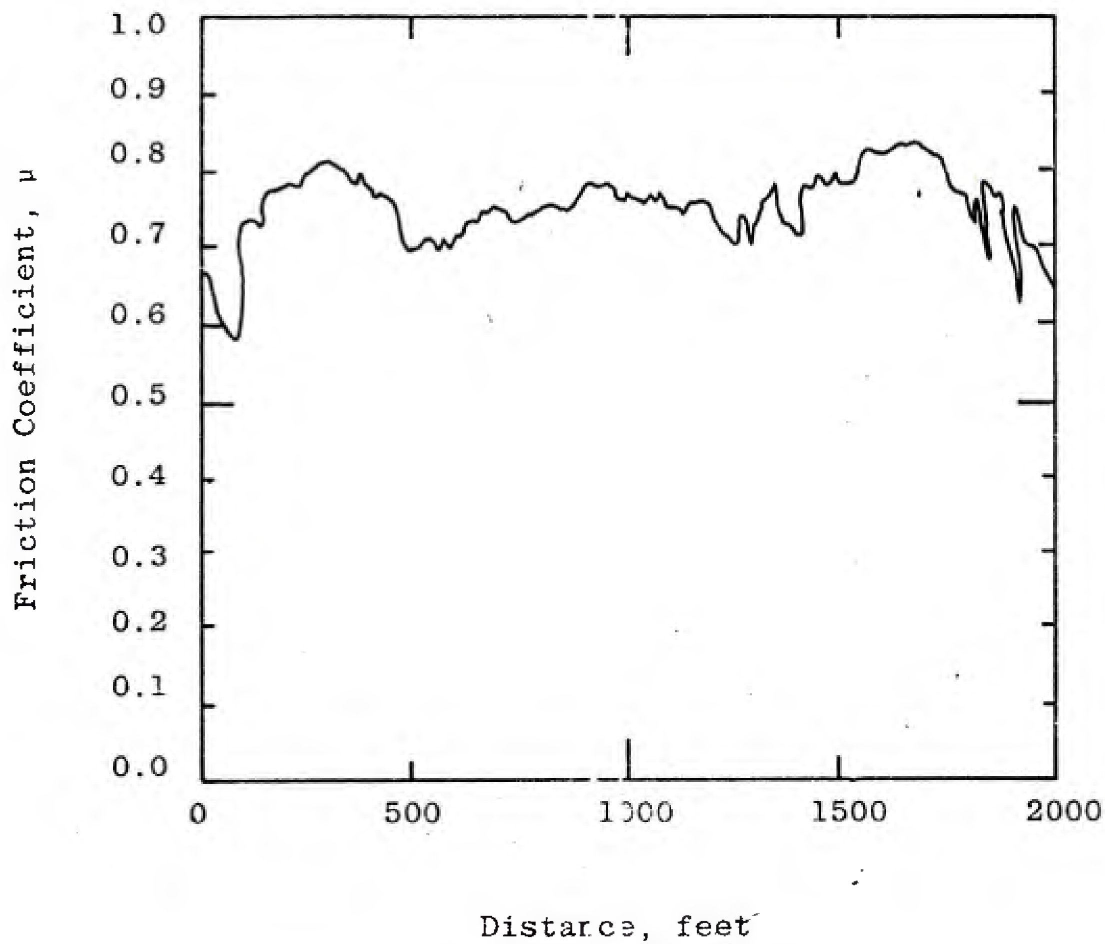
Runway and Test Section	Station	Offset from Runway Centerline
Runway 6L-24R		
A	5+00 to 15+00	10' left
B	25+00 to 35+00	10' left
C	55+00 to 75+00	10' right
D	100+00 to 110+00	10' right
Runway 6R-24L		
A	5+00 to 25+00	10' left
B	40+00 to 60+00	10' left
C	65+00 to 75+00	10' right



FRICTION TEST LOCATIONS

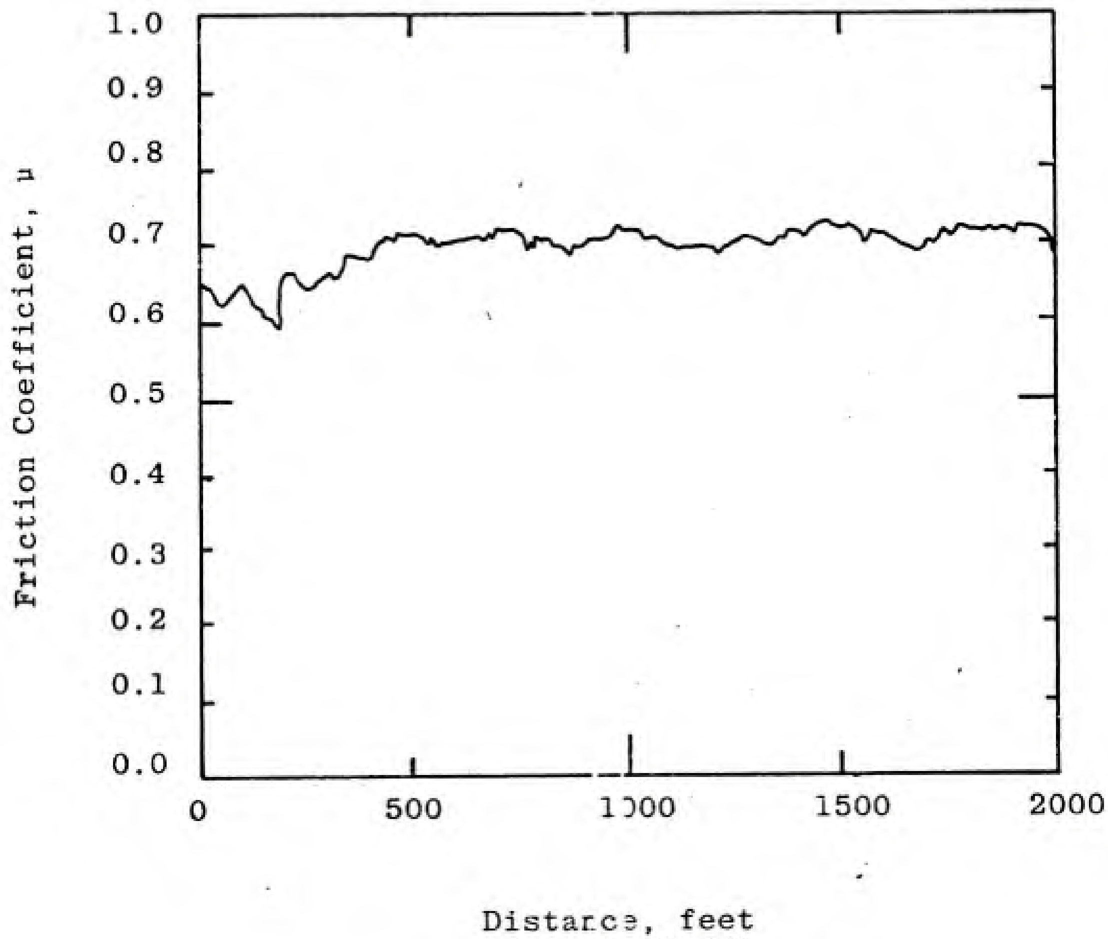
USNAS MIRAMAR, CALIF.

FIGURE 14



Runway 6R-24L
Test Section A, Run 1

Figure 15. Friction Coefficient versus Distance, USNAS Miramar, California



Runway 6R-24L
Test Section B, Run 1

Figure 16. Friction Coefficient versus Distance, USNAS Miramar, California

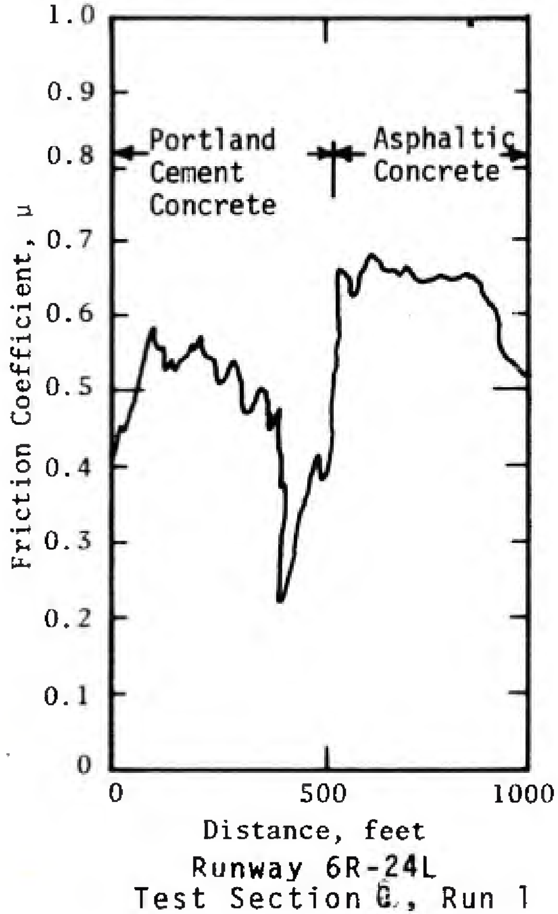
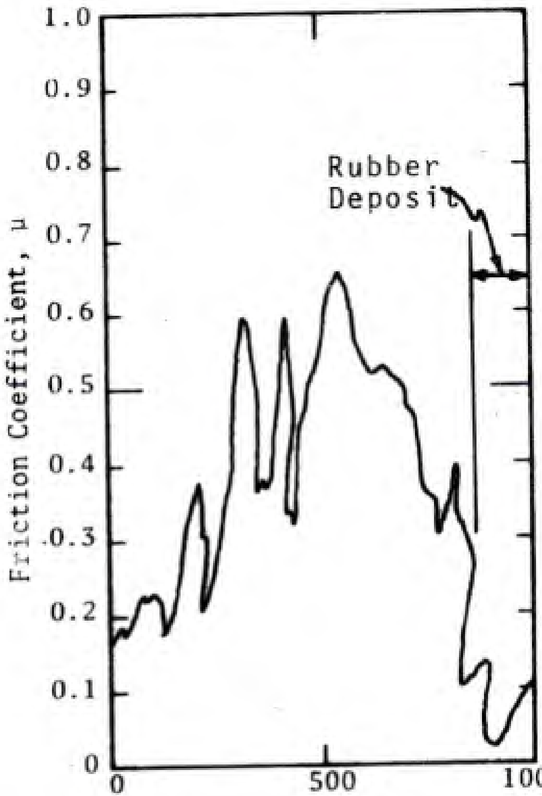
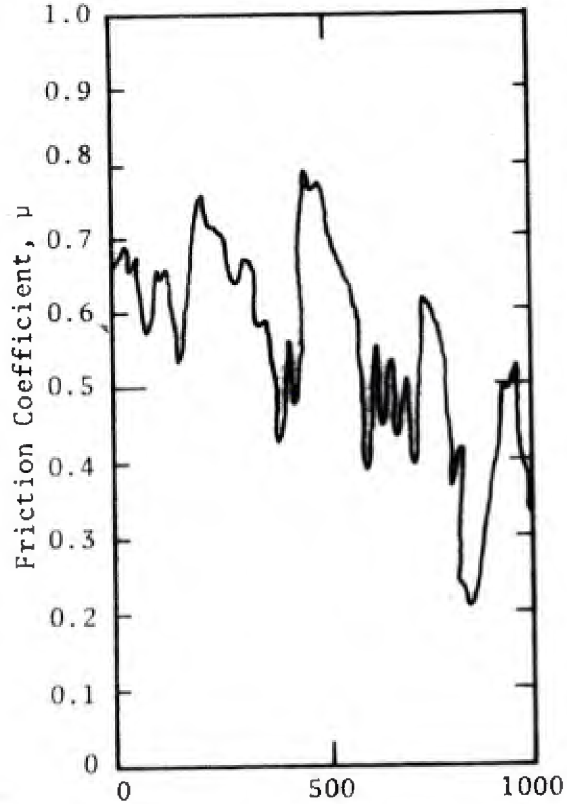


Figure 17. Friction Coeffieicent versus Distance, USNAS Miramar, California

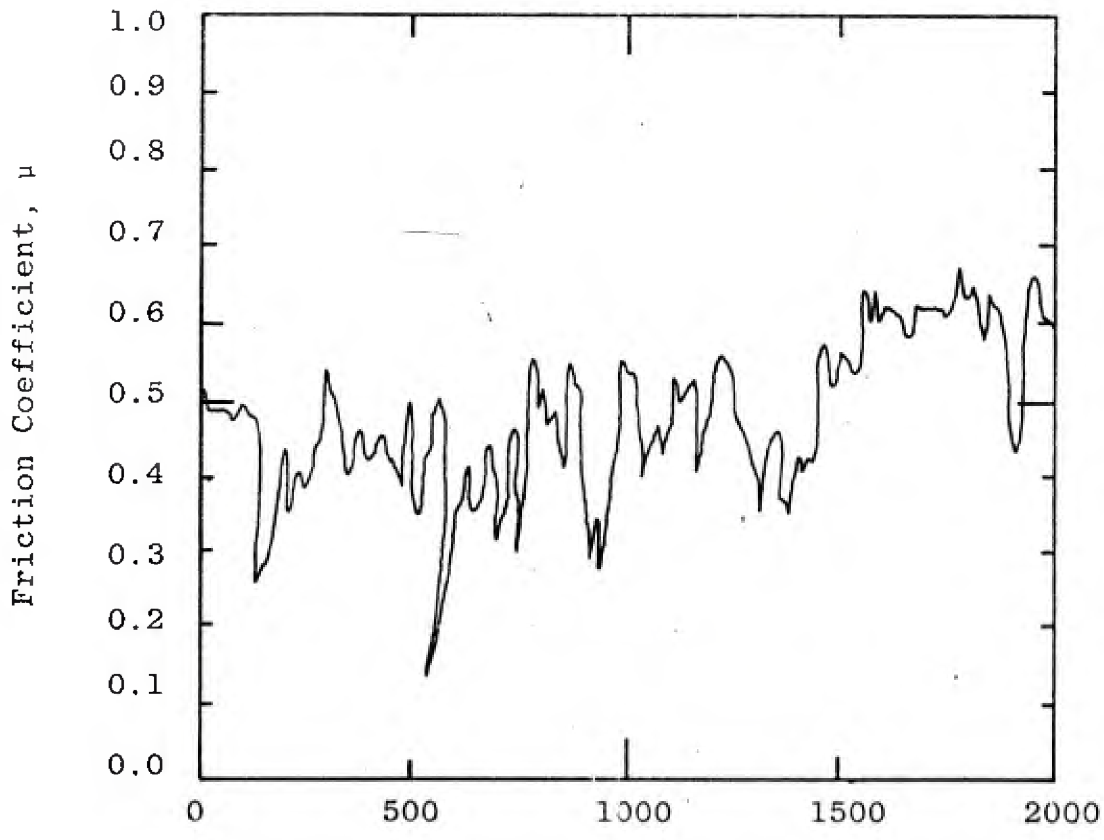


Distance, feet
Runway 6L-24R
Test Section A, Run 1



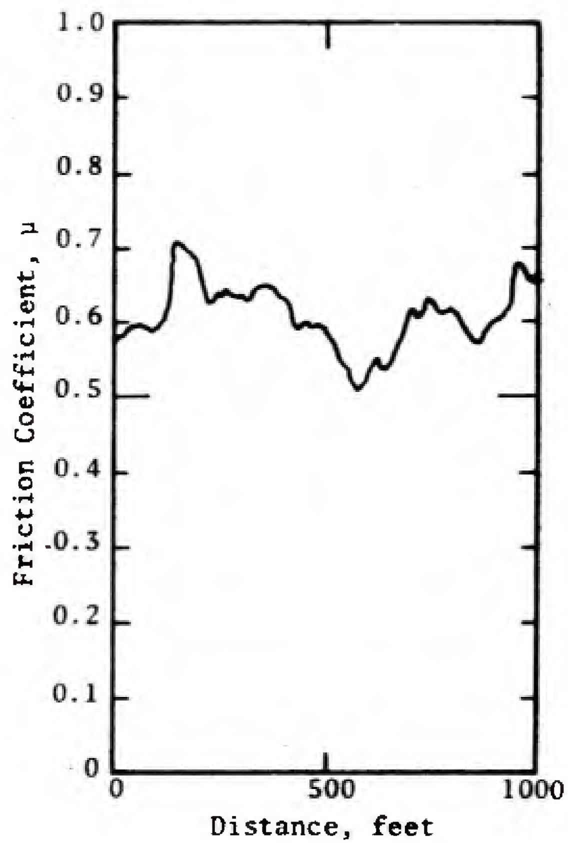
Distance, feet
Runway 6L-24R
Test Section B, Run 1

Figure 18. Friction Coefficient versus Distance, USNAS Miramar, California



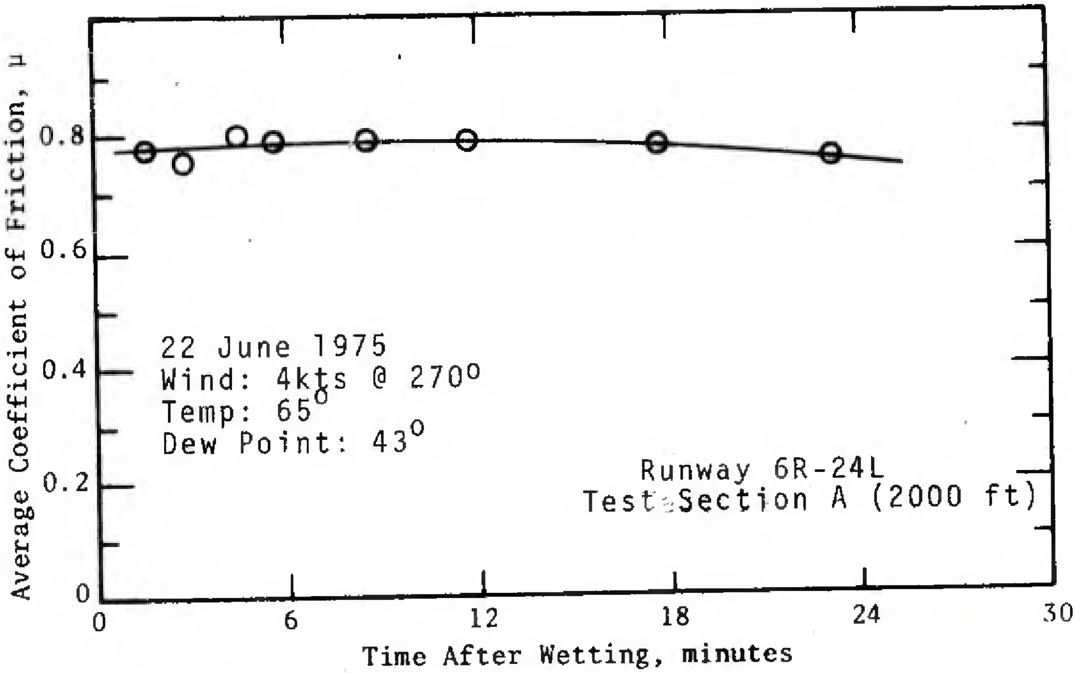
Runway 6L-24R
Test Section C, Run 1

Figure 19. Friction Coefficient versus Distance, USNAS Miramar, California



Runway 6L-24R
Test Section D, Run 1

Figure 20. Friction Coefficient versus Distance, USNAS Miramar, California



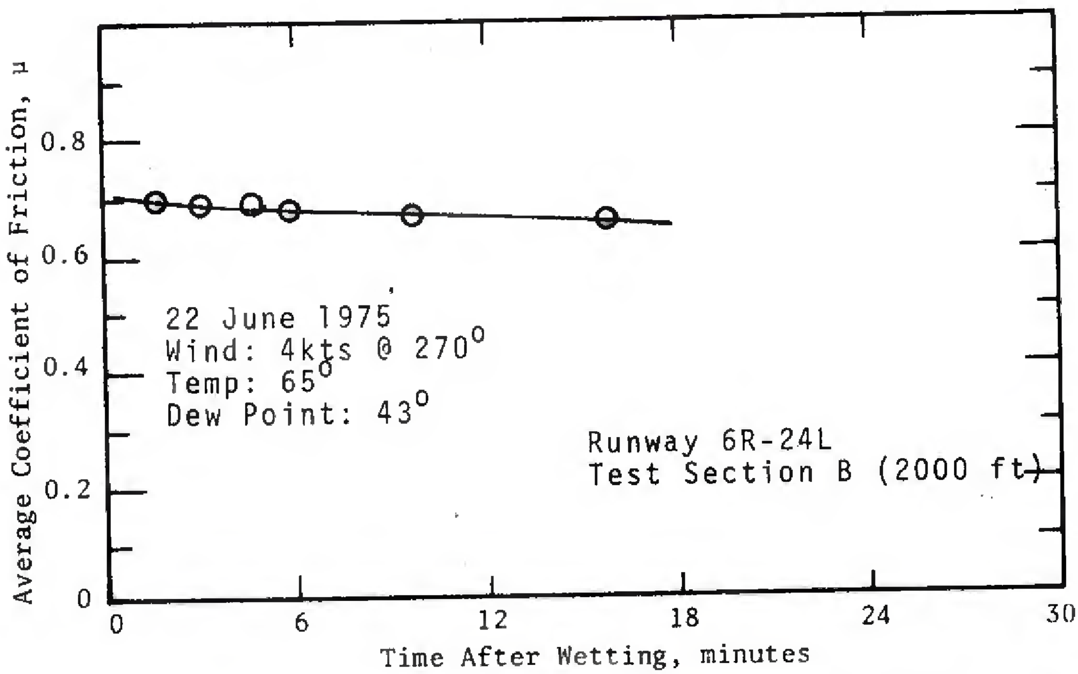
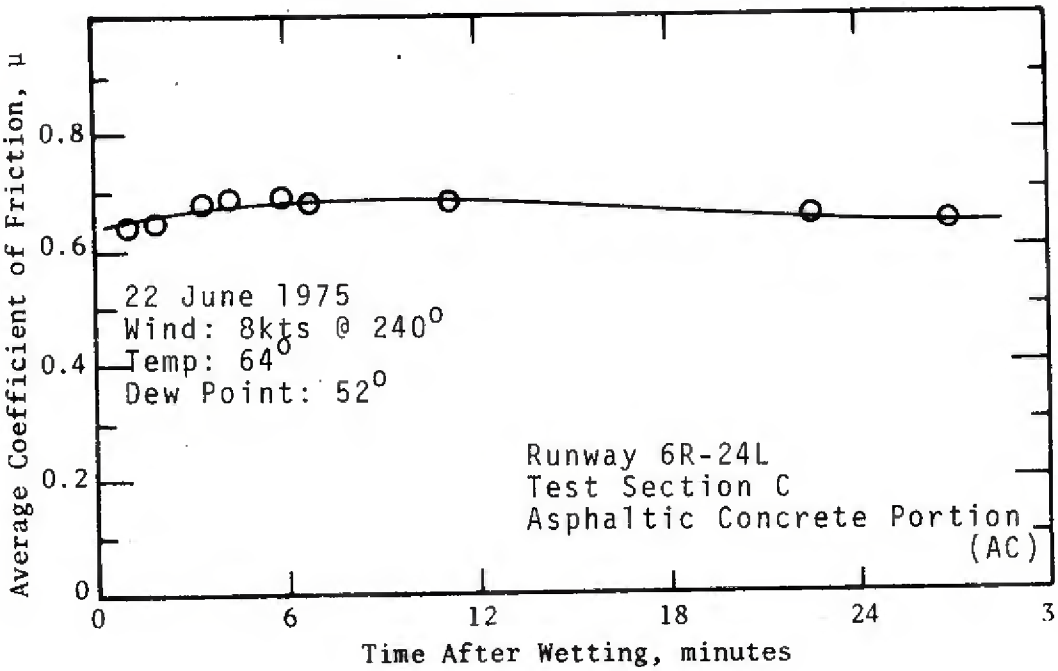


Figure 21. Average Friction Coefficient Versus Time After Wetting, USNAS Miramar, California



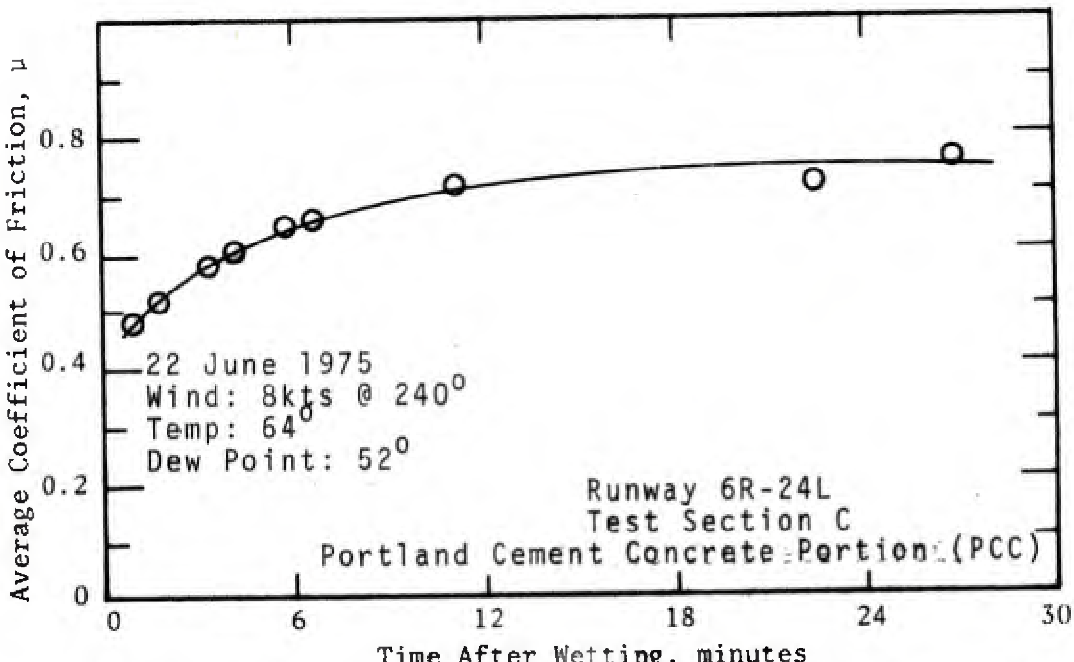
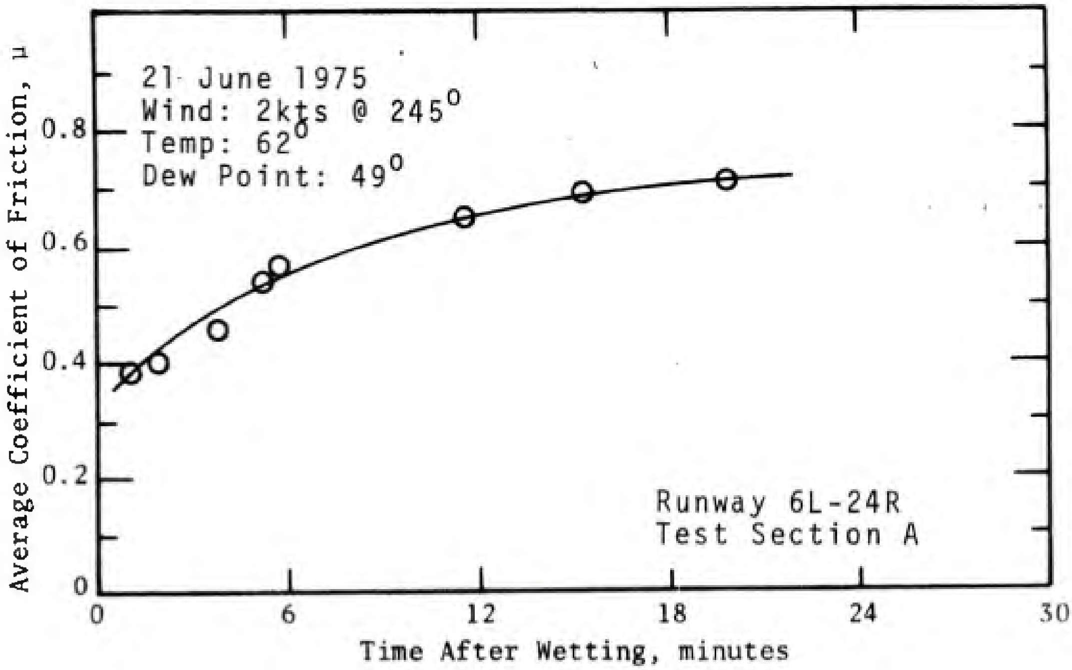


Figure 22. Average friction Coefficient Versus Time After Wetting, USNAS Miramar, California



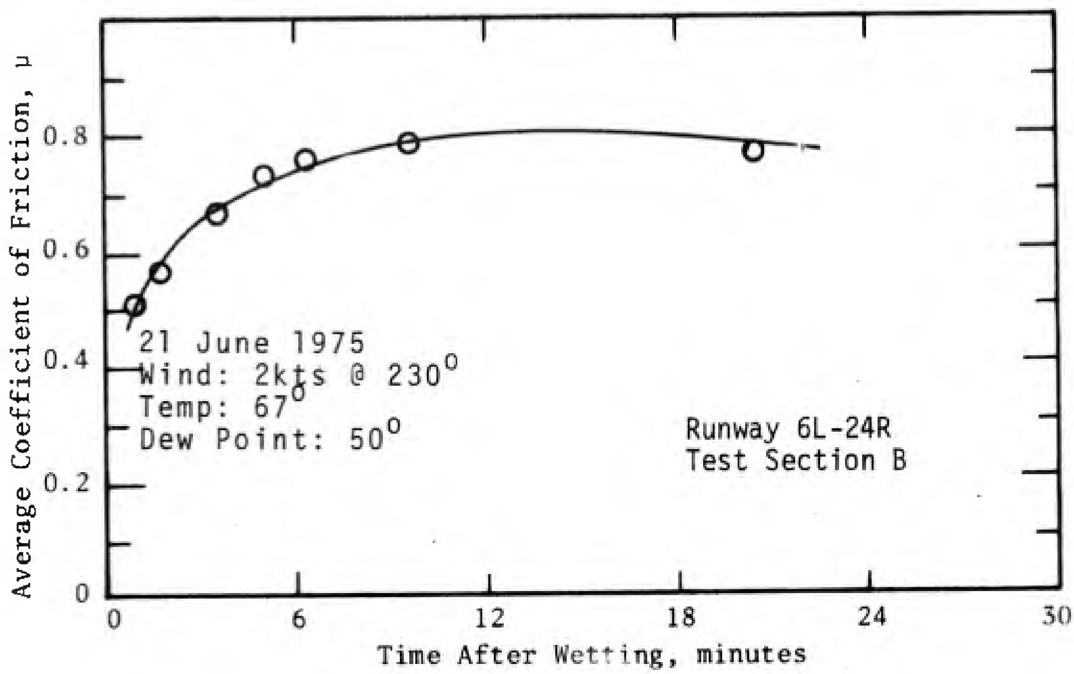
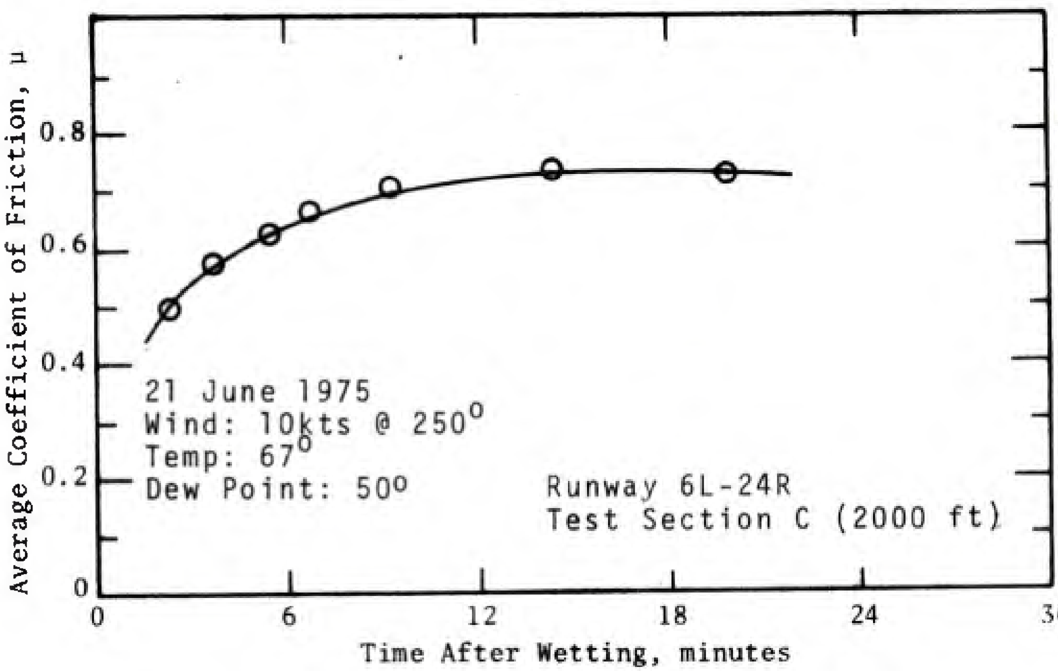


Figure 23. Average Friction Coefficient versus Time After Wetting, USNAS Miramar, California



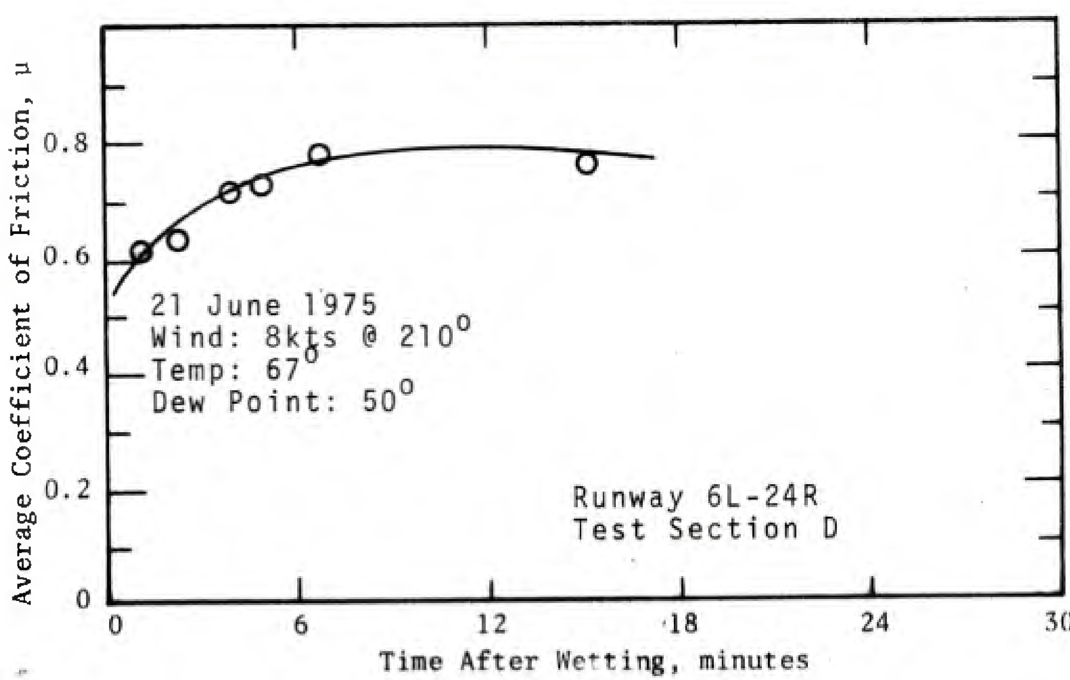


Figure 24. Average Friction Coefficient versus Time After Wetting, USNAS Miramar, California

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNAS Miramar Facility Runway 6R-24L

Discrete Area R24L-3 Area of Discrete Area (a) 347, 800 ft²

No. of Sample Areas (b) 14 Ratio: (a/2500b) 9.94

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*					
Reflection Crack					
Faulting					
Patching	No Defects Measured				
Settlement or Depression					
Pattern Cracking					
Rutting					
Raveling					
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	

**

Remarks on Pavement Condition

The rubber-asphalt seal coat placed in October, 1974 has covered any cracks. The seal coat is losing some aggregate, necessitating periodic sweeping (See Figure 3). The application of chips during the construction of the seal coat was apparently uneven as evidenced by a washboard effect in some lanes (see Figure 4).

* Transverse crack, longitudinal crack or longitudinal construction joint crack.

** Letter suffix "A" indicates asphaltic pavement.

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNAS Miramar Facility Runway 6R-24L

Discrete Area R24 L-1 Total Slabs in Discrete Area (a) 1072

No. of Slabs Sampled (b) 178 Ratio a/b = 6.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	16	96	0.0896	7.5	0.672
Scaling					
Shattered Slab					
Joint Seal	85	510	0.4757	3.0	1.427
Pumping					
"D-line" cracking					
				Total	2.10C***

Remarks on Pavement Condition

Joint seal was very hard and occasionally was burned by jet blast (see Figure 5). Many spalls had been repaired during 1974 and most repairs were effective (see Figure 6). The remaining spalls were generally small, 1" to 4" in length and less than 1" wide. A moderately heavy buildup of rubber was noted on the 24 end of the runway.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNAS Miramar Facility Runway 6R-24L

Discrete Area R24 L-2 Total Slabs in Discrete Area (a) 1112

No. of Slabs Sampled (b) 185 Ratio a/b = 6.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*	2	12	0.0108	1.5	0.016
I.C.**					
Depression					
Spalling	6	36	0.0324	7.5	0.243
Scaling					
Shattered Slab					
Joint Seal	185	1112	1.00	3.0	3.00
Pumping					
"D-line" cracking					
				Total	3.26C***

Remarks on Pavement Condition

The joint seal was shriveled and hardened. The joint seal had lost bond in some joints. Most spalls were small, less than one inch wide. The rubber buildup in the FCLP area is very heavy (see Figure 7). It is possible to peel up strips of rubber 1/32" to 1/16" thick.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNAS Miramar Facility Runway 6L-24R

Discrete Area R24 R-1 Total Slabs in Discrete Area (a) 3544

No. of Slabs Sampled (b) 177 Ratio a/b = 20.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*	1	20	0.006	1.5	0.009
I.C.**					
Depression					
Spalling	16	320	0.090	7.5	0.677
Scaling					
Shattered Slab					
Joint Seal	177	3544	1.00	3.0	3.000
Pumping					
"D-line" cracking					
				Total	3.69C***

Remarks on Pavement Condition

Spalls ranged up to 4" wide and 12" long (see Figure 8). Some of the spalls noted were on old spall repairs. Spall repairs with the date 1972 on them were in generally good condition. The joint seal was hardened over the entire area and was burned and blown at the runway end (see Figure 9).

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNAS Miramar Facility Runway 6L-24R

Discrete Area R24 R-2 Total Slabs in Discrete Area (a) 1064

No. of Slabs Sampled (b) 266 Ratio a/b = 4.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*	3	12	0.0112	1.5	0.017
I.C.**					
Depression	41	164	0.1541	7.5	1.156
Spalling					
Scaling					
Shattered Slab					
Joint Seal	266	1064	1.00	3.0	3.000
Pumping					
"D-line" cracking					
				Total	4.17C ***

Remarks on Pavement Condition

The joint seal was hardened and shriveled over almost the entire area (see Figure 10). Approximately 50 percent of the spalls noted were located on repaired areas.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNAS Miramar Facility Runway 6L-24R

Discrete Area R24 R-3 Total Slabs in Discrete Area (a) 1600

No. of Slabs Sampled (b) 160 Ratio a/b = 10.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	15	150	0.0937	7.5	0.703
Scaling					
Shattered Slab					
Joint Seal	160	1600	1.00	3.0	3.000
Pumping					
"D-line" cracking					
				Total	3.70C***

Remarks on Pavement Condition

The joint seal was hardened and shriveled. Joint was completely missing from a few joints. Spalls were primarily located on slab corners (see Figure 11).

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNAS Miramar Facility Runway 6L-24R

Discrete Area R24 R-4 Total Slabs in Discrete Area (a) 528

No. of Slabs Sampled (b) 132 Ratio a/b = 4.00

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	21	84	0.1590	7.5	1.192
Scaling					
Shattered Slab					
Joint Seal	132	528	1.00	3.00	3.000
Pumping					
"D-line" cracking					
				Total	4.19C ***

Remarks on Pavement Condition

Joint seal was hardened and shriveled (see Figure 12). Many spalls were located on transverse expansion joints.

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield USNAS Miramar Facility Runway 10-28

Discrete Area R28-1 Total Slabs in Discrete Area (a) 3200

No. of Slabs Sampled (b) 160 Ratio a/b = 20.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break					
L.C. or T.C.*					
I.C.**					
Depression					
Spalling	15	300	0.094	7.5	0.703
Scaling					
Shattered Slab					
Joint Seal	32	640	0.0200	3.0	0.600
Pumping					
"D-line" cracking					
				Total	***

Remarks on Pavement Condition

Most spalls noted were on old epoxy repairs. Most spalls were small, less than 2" wide. The joint seal was pliable and performing adequately. Vegetation growing in the joints was the only joint seal defect noted (see Figure 13).

* Longitudinal crack or Transverse crack
** Intersecting crack
*** Letter suffix "C" represents PCC pavement

PORTLAND CEMENT CONCRETE FACILITY DEFECT SUMMARY

Airfield USNAS Miramar, California

Date Surveyed November 1974

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)	(b)	(c)**
1974 Condition Survey			
Runway 6R-24L			
R24L-1	2.10C	0.49	1.03
R24L-2	3.26C	0.51	1.66
			2.69C (Total)
Runway 6L-24R			
R24R-1	3.69C	0.57	2.10
R24R-2	4.17C	0.085	0.35
R24R-3	3.70C	0.26	0.96
R24R-4	4.19C	0.085	0.36
			3.77C (Total)
Runway 10-28			
R28-1	1.30	1.00	1.30C
1970 Condition Survey			
Runway 6R-24L			
R24L-1	2.88C	0.49	1.41
R24L-2	4.46C	0.51	2.27
			3.68C (Total)
Runway 6L-24R			
R24R-1	2.71C	0.51	1.54
R24R-2	1.82C	0.085	0.15
R24R-3	1.58C	0.26	0.41
R24R-4	3.19C	0.085	0.27
			2.37C (Total)
Runway 10-28			
R28-1	2.97	1.00	2.97C

* If facility entirely constructed of PCC, indicates total facility area. If facility only partly constructed of PCC, indicates total area of PCC portion of facility.

** Letter suffix "C" on average weighted defect densities indicates Portland cement concrete pavements.

PORTLAND CEMENT CONCRETE FACILITY DEFECT SUMMARY

Airfield USNAS Miramar, California

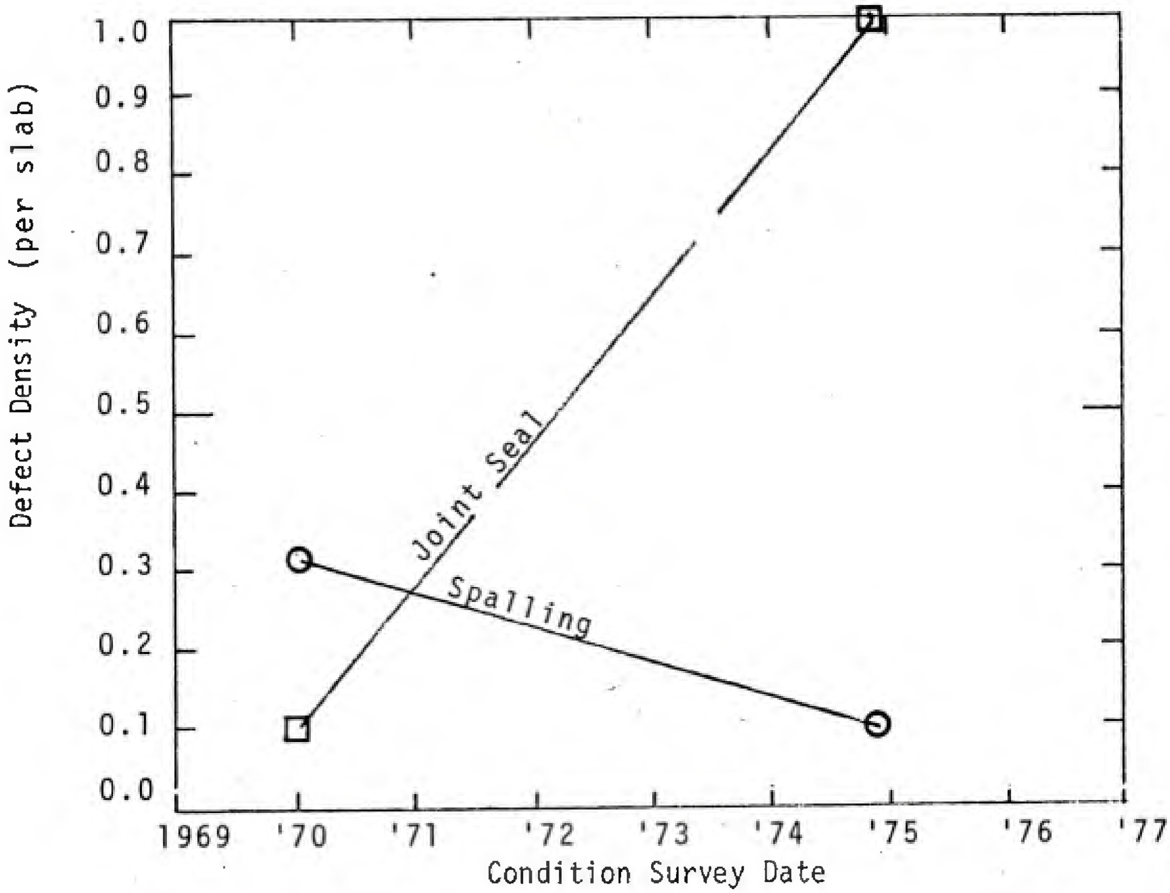
Date Surveyed November 1974

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
1974 Condition Survey			
Runway 6R-24L			
R24L-3	0.00A	1.00	0.00A
1970 Condition Survey			
R24L-3	0.11A	1.00	0.11A

* If facility entirely constructed of PCC, indicates total facility area. If facility only partly constructed of PCC, indicates total area of PCC portion of facility.

** Letter suffix "C" on weighted defect densities indicates Portland cement concrete pavements.

DISCRETE AREA CONDITION ANALYSIS



Airfield NAS Miramar
Facility Runway 6L-24R
Discrete Area R24R-1
Pavement Type PCC

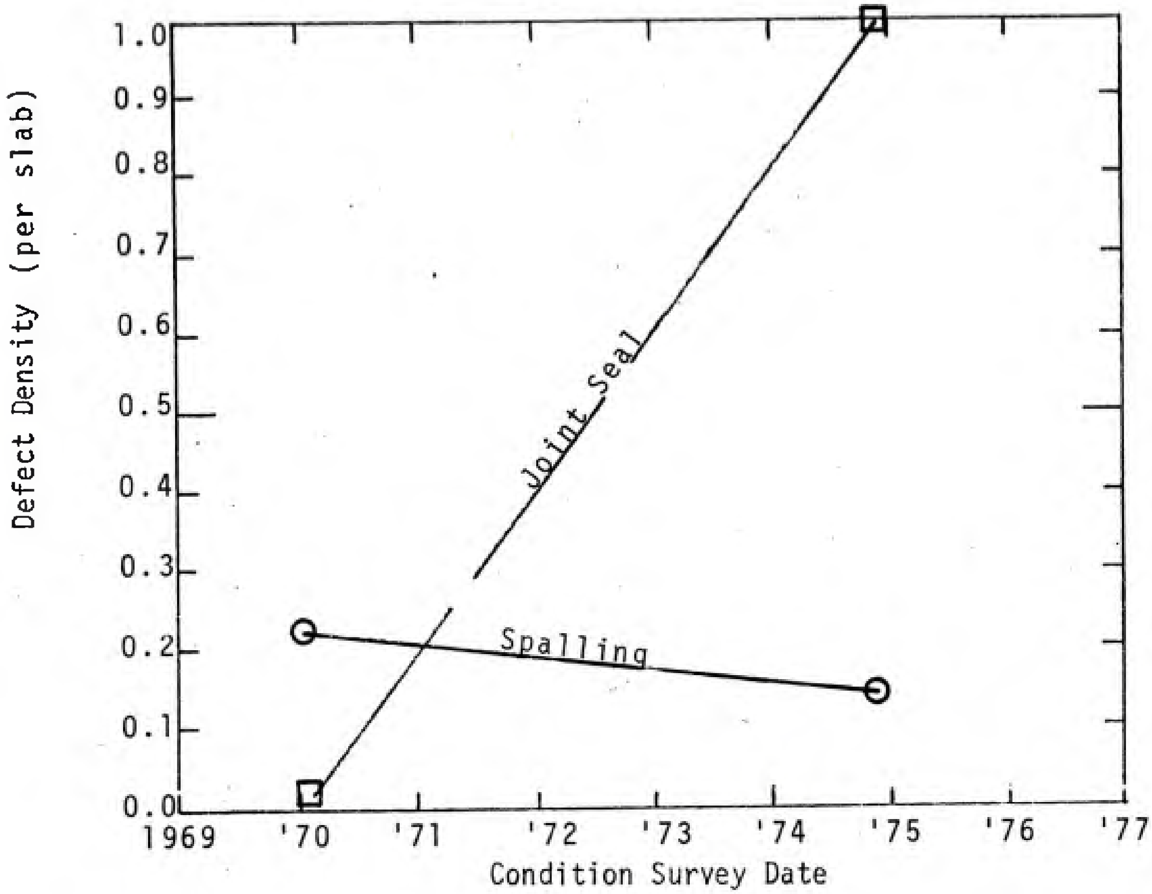
Discussion

The increase in the amount of defective joint seal is attributed to effects of aging and oxidation. Most of the joint seal was placed 14 years ago.

A continuing program of spall repairs has reduced the incidence of spalling substantially.

Other defects noted in the survey are not significant and are not included in this analysis.

DISCRETE AREA CONDITION ANALYSIS



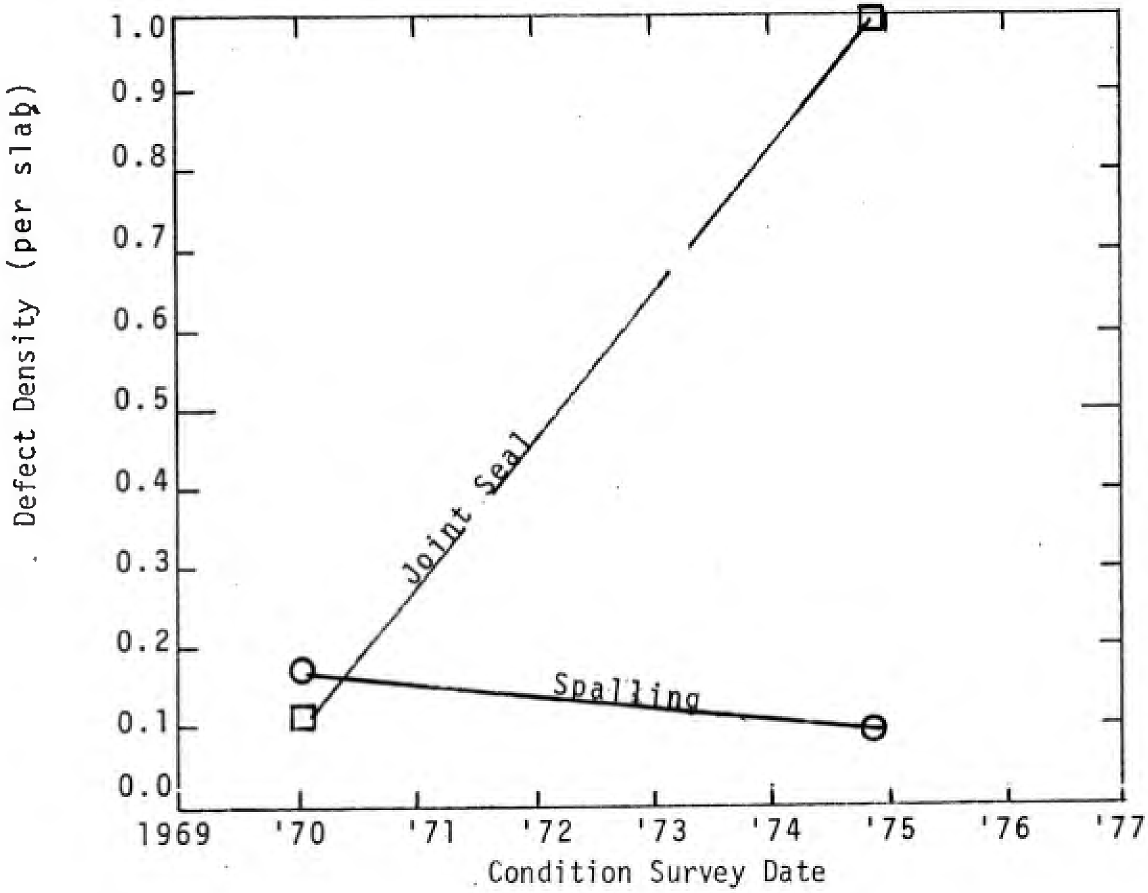
Airfield NAS Miramar | Facility Runway 6L-24R

Discrete Area R24R-2 | Pavement Type PCC

Discussion

Increased joint seal defects were attributed to aging and oxidation. Spall repairs have decreased the incidence of spalling.

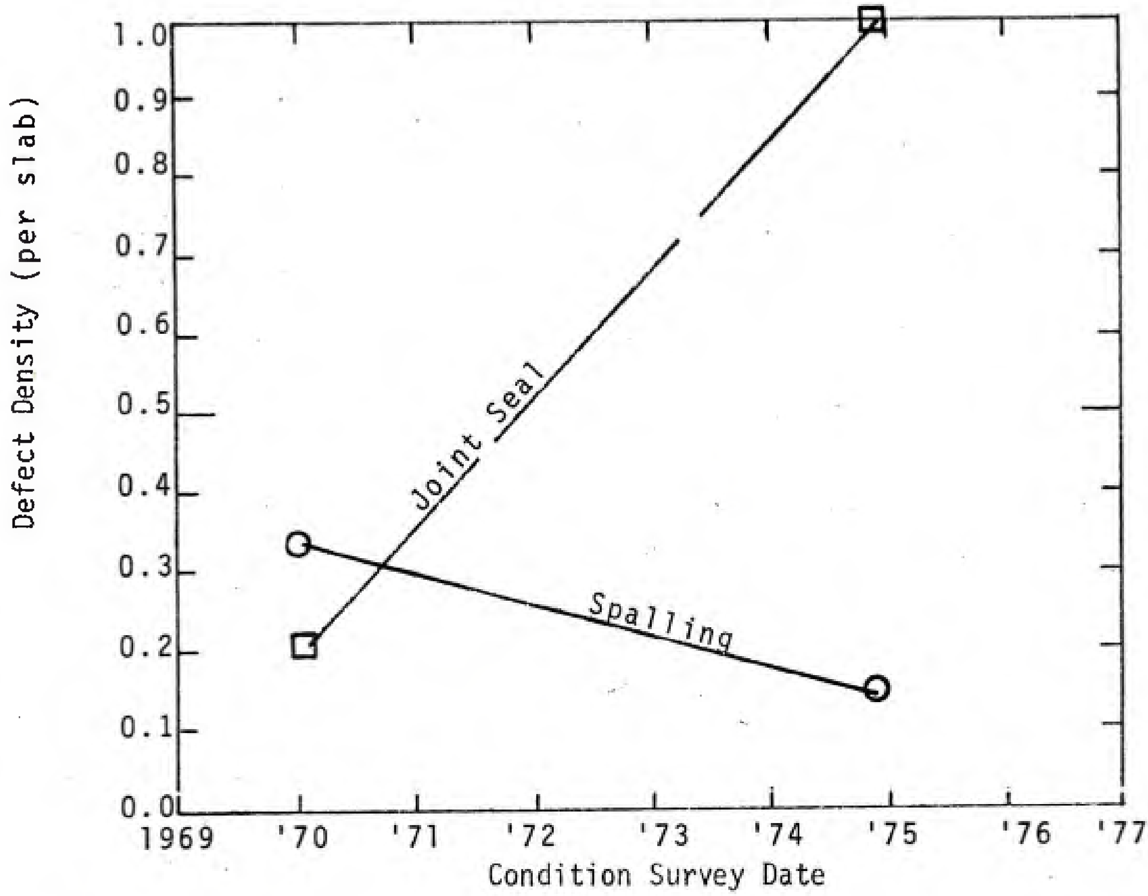
DISCRETE AREA CONDITION ANALYSIS



Airfield NAS Miramar Facility Runway 6R-24L
Discrete Area R24R-3 Pavement Type OCC
Discussion

Increased joint seal defects were attributed to aging and oxidation. Spall repairs have decreased the incidence of spalling.

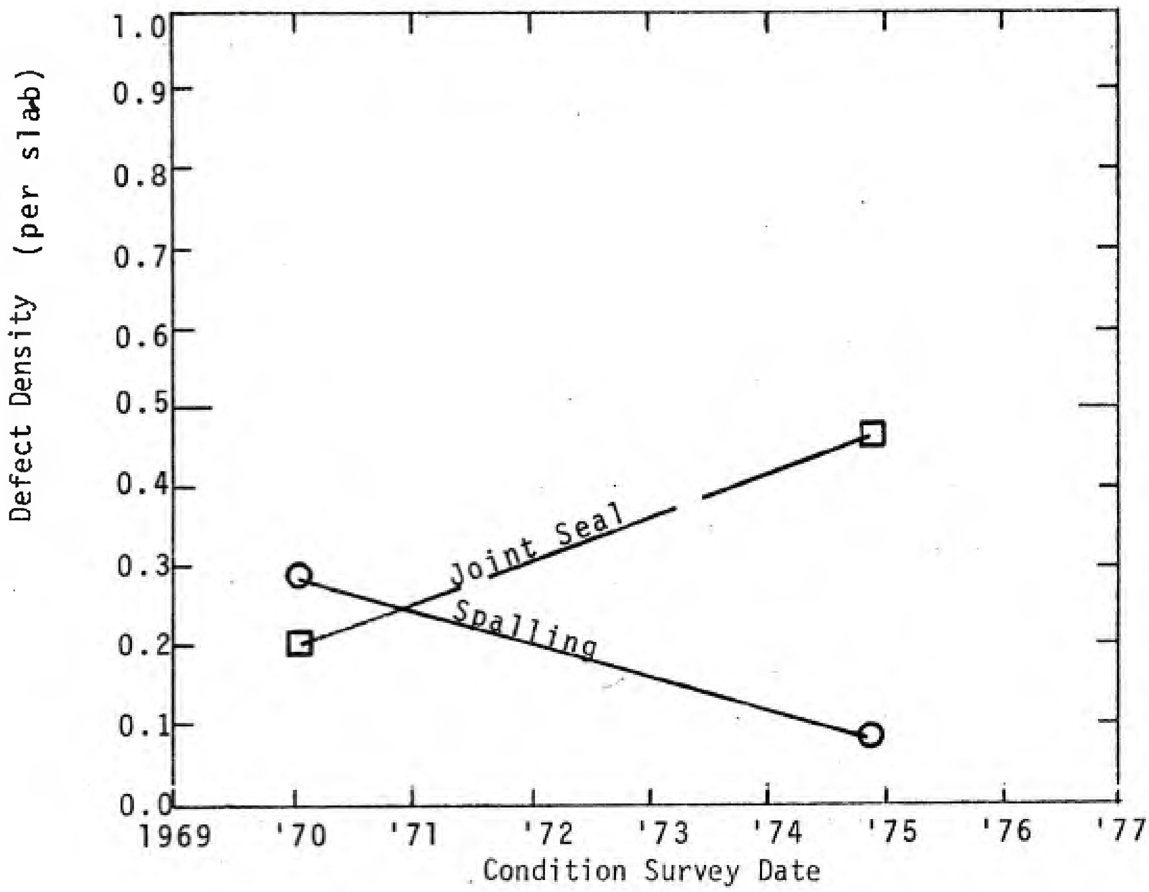
DISCRETE AREA CONDITION ANALYSIS



Airfield NAS Miramar Facility Runway 6L-24R
Discrete Area R24R-4 Pavement Type PCC
Discussion

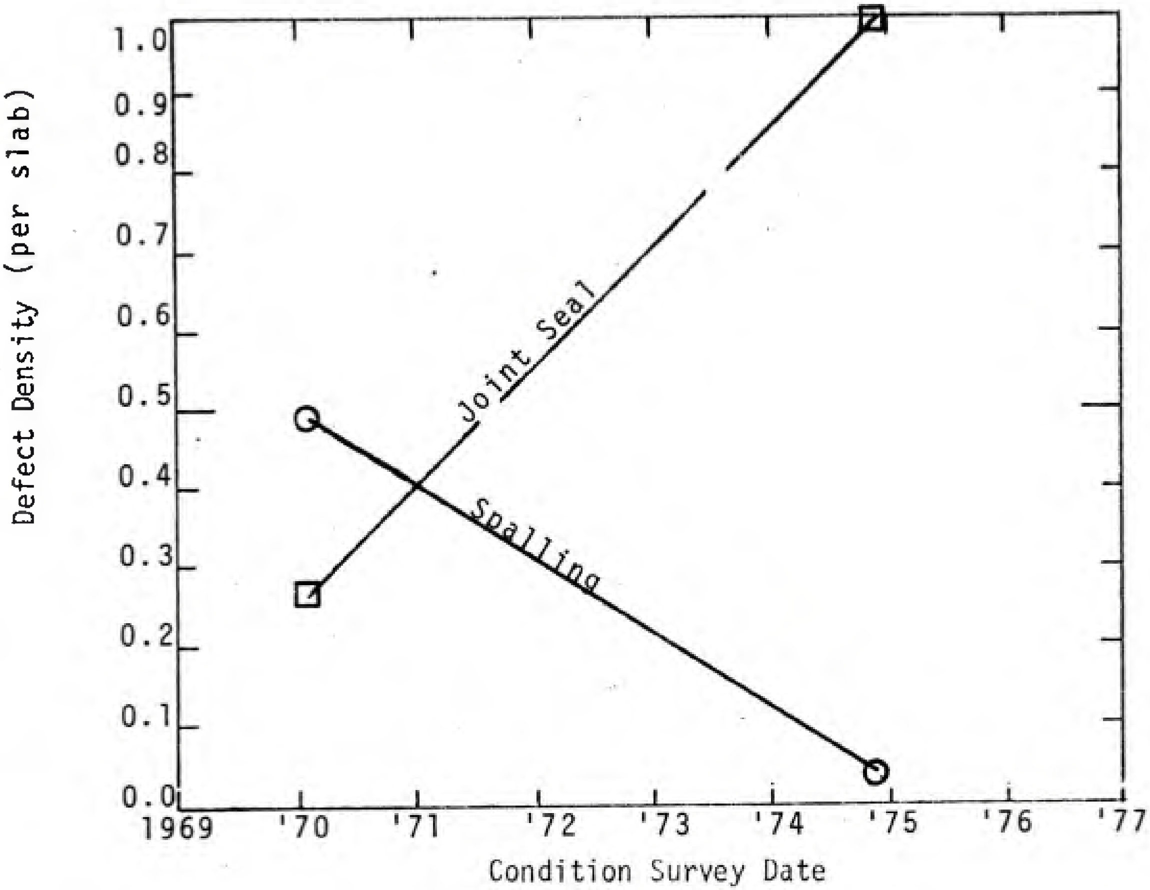
Increased joint seal defects were attributed to aging and oxidation. Spall repairs have decreased the incidence of spalling.

DISCRETE AREA CONDITION ANALYSIS



Airfield NAS Miramar Facility Runway 6R-24L
Discrete Area R 24L-1 Pavement Type PCC
Discussion

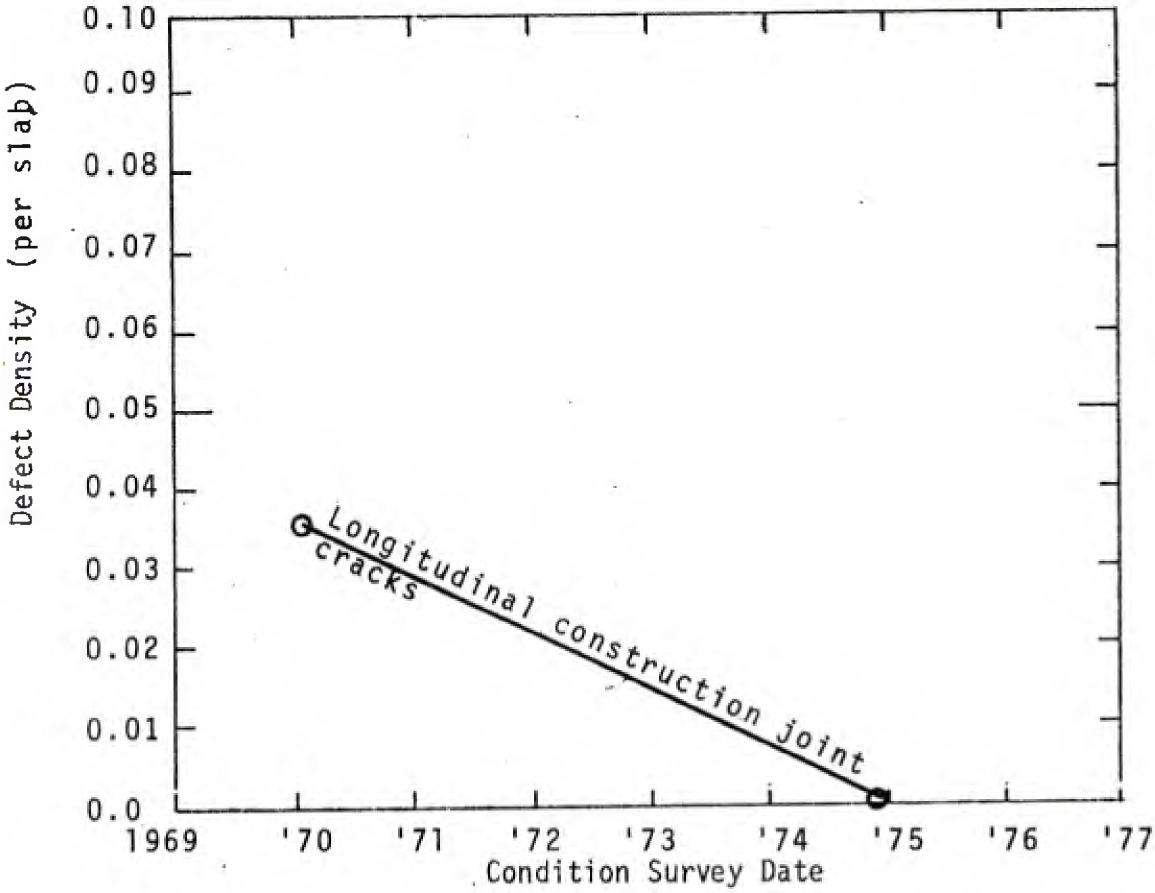
Joint seal defects have increased primarily due to age and oxidation. Spall repairs completed in 1974 have decreased the incidence of spalling.



Airfield NAS Miramar — Facility Runway 6R-24L
Discrete Area R24L-2 — Pavement Type PCC
Discussion

Joint seal defects have increased primarily due to age and oxidation. Spall repairs completed in 1974 have decreased the incidence of spalling.

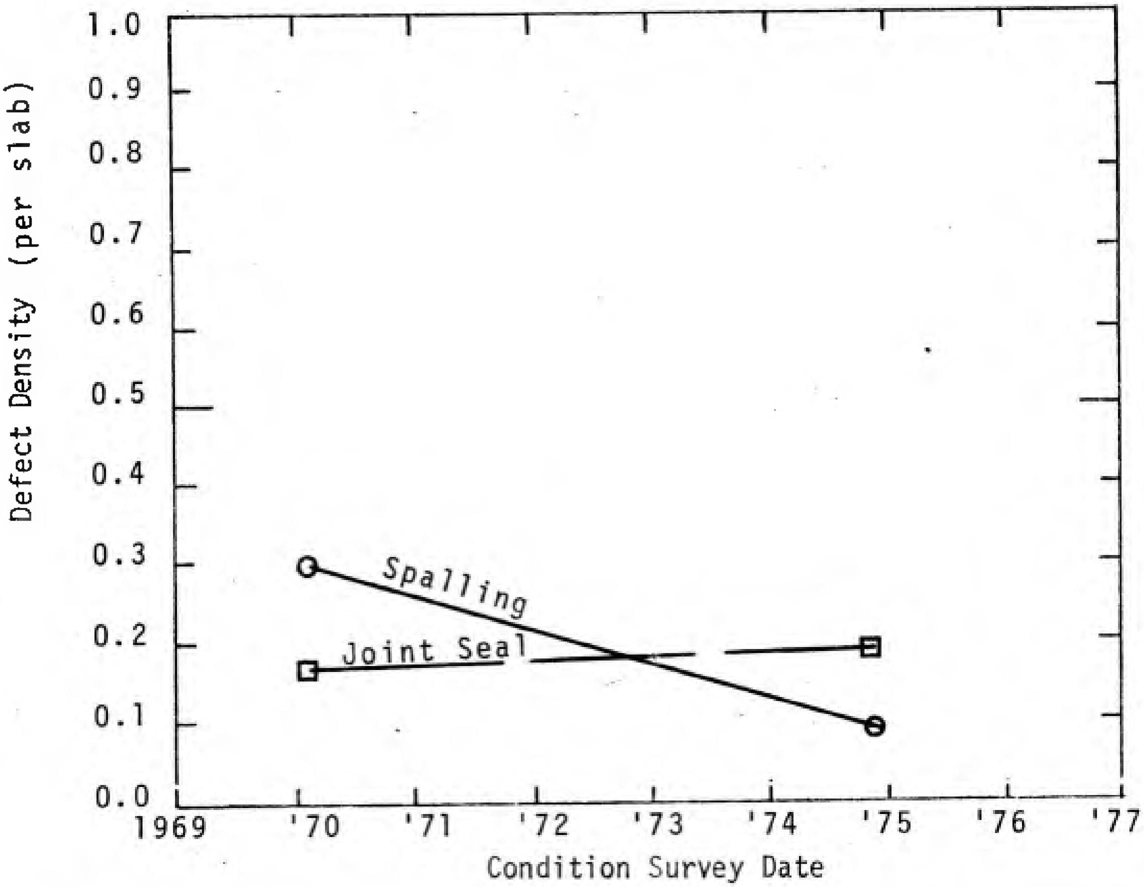
DISCRETE AREA CONDITION ANALYSIS



Airfield NAS Miramar Facility Runway 6R-24L
Discrete Area R24L-3 Pavement Type AC
Discussion

The rubber asphalt seal coat placed in October 1974 has covered the cracks measured in 1970. See the discrete area summary R24L-3 for additional comments.

DISCRETE AREA CONDITION ANALYSIS



Airfield NAS Miramar Facility Runway 10-28
Discrete Area R28-1 Pavement Type PCC
Discussion

Repairs have apparently reduced the number of spalls noted on this seldom-used runway.

Appendix A

CONSTRUCTION HISTORY

APPENDIX A

CONSTRUCTION HISTORY FOR USNAS MIRAMAR, CALIFORNIA

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
1	Runway 10-28		
	Spalls repaired with epoxy concrete and joints resealed with SS-S-164		1967
	12" Portland cement concrete	1943	
	10" Base crusher run	1943	
	4" Plant mix	1943	
	Shoulders (150' wide):		
	Slurry seal		1956
	Seal coat first 50'		1946
	2" Asphaltic concrete	1943	
	24" Base	1943	
2	Runway 6R-24L		
	Rubber-asphalt seal coat		1974
	2" Asphaltic concrete overlay		1965
	Seal coat		1954
	3" Asphaltic concrete	1951	
	9" Base	1951	
	15" Subbase	1951	
2A	Runway 6R-24L (Ends)		
	Rubber removal		1975
	Spalls repaired by Public Works		1974
	Rubber removal		1973
	Spalls repaired at various times by Public Works		--
	Joints resealed (SS-S-200a in first 500' on 24 end, SS-S-164 in remainder)		1961
	12" Portland cement concrete	1951	
	12" Base	1951	
	12" Subbase(compacted native material)	1951	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
	Shoulders (50' wide):		
	2" Asphaltic concrete		1954
	Seal coat		1954
	Oil penetration	1951	
	24" Subbase	1951	
2B	<u>Runway 6R-24L (Asphaltic Concrete Pavement Removed)</u>		
	Rubber removal		1975
	Rubber removal		1973
	Continuing spall repairs by Public Works		--
	Joints resealed (SS-S-200b)		1963
	11" Portland cement concrete	1960	
	6" Base and subbase (material compacted 95% AASHO)	1960	
	<u>Runway 6R-24L (Overrun)</u>		
	8" Base compacted 95% AASHO on 6" compacted native material	1960	
3	<u>Runway 6L-24R</u>		
	Rubber removal		1975
	Rubber removal		1973
	Continuing spall repairs by Public Works		--
	Joints resealed and spalls repaired (SS-S-200b in first 500' on 24 end, SS-S-164 in second 500' on 24 end)		1963
	Joints resealed and spalls repaired (SS-S-164 in remaining 5000')		1961
	12" Portland cement concrete	1944	
	10" Base crusher run	1944	
	4" Plant mix	1944	
	Shoulders (50'):		
	Slurry seal		1956
	Seal coat first 50'		1946
	2" Asphaltic concrete	1943	
	24" Base	1943	

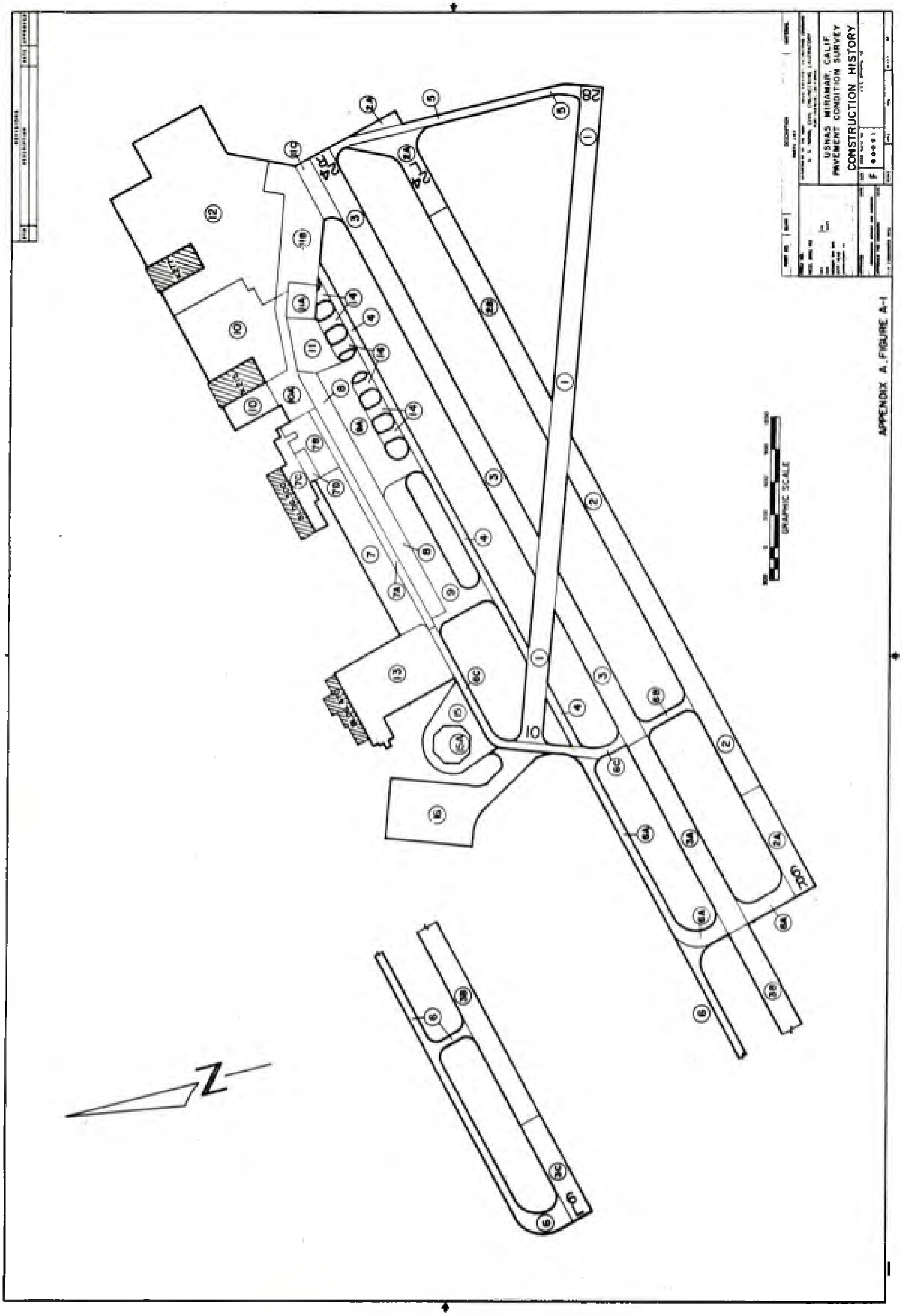
Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
3A	Runway 6L-24R (Extension)		
	12" Portland cement concrete	1951	
	12" Base	1951	
	12" Subbase	1951	
3B	Runway 6L-24R (Extension)		
	11" Portland cement concrete	1959	
	10" Base crusher run	1959	
	6" Compacted fill on 6" compacted native material	1959	
3C	Runway 6L-24R (End)		
	13" Portland cement concrete	1959	
	10" Base crusher run	1959	
	6" Compacted fill on 6" compacted native material	1959	
	Shoulders 50':		
	Slurry seal		1956
	2" Asphaltic concrete	1951	
	22" Subbase	1951	
	Overrun:		
	8" Subbase material	1959	
4	Taxiway 5 (75' wide)		
	12" Portland cement concrete	1951	
	12" Base	1951	
	12" Subbase (compacted native material)	1951	
	Shoulders (25" wide):		
	Slurry seal		1956
	Slurry seal		1952
	Seal coat		1946
	2" Asphaltic concrete	1943	
	22" Subbase	1943	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
5	12" Portland cement concrete	1944	
	10" Base	1944	
	Shoulders:		
	Slurry seal		1956
	Seal coat		1946
	2" Asphaltic concrete	1944	
	24" Base	1944	
6	Taxiway 1		
	13" Portland cement concrete	1959	
	10" Base	1959	
	6" Compacted native material	1959	
	Shoulders 25' wide:		
	24" Compacted fill	1959	
	6" Compacted native material	1959	
6A	Taxiway 1		
	12" Portland cement concrete	1951	
	12" Base	1951	
	12" Subbase (Compacted native material)	1951	
	4" Plant mix	1951	
6B	Taxiway 1		
	2" Overlay (on 3" exist, NOY 27062)		1965
	3" Asphaltic concrete	1951	
	9" Base	1951	
	15" Subbase	1951	
	Shoulders 25' wide:		
	2" Overlay	1954	
	12" Native compacted material	1954	
6C	Taxiway 1		
	12" Portland cement concrete	1944	
	10" Crusher run base	1944	
	4" Plant mix	1944	

Item No.	Section from Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
7	Parking Apron 1		
	12" Portland cement concrete	1951	
	12" Base	1951	
	12" Subbase (compacted native material)	1951	
7A	Parking Apron 1		
	12" Portland cement concrete	1944	
	10" Base crusher run	1944	
	4" Plant mix	1944	
7B	Parking Apron 1		
	12" Portland cement concrete	1962	
	12" Base	1962	
	6" Compacted native material	1962	
7C	Parking Apron 1		
	9" Portland cement concrete	1969	
	6" Base	1969	
	6" Compacted native material	1969	
7D	Parking Apron 1		
	8" Portland cementconcrete	1953	
	12" Select base material	1953	
8	Parking Apron 2		
	8" Portland cement concrete	1944	
	12" Base crusher run	1944	
9	Parking Apron 3		
	10" Portland cement concrete	1954	
	8" Base	1954	
	6" Subbase (compacted native material)	1954	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
9A	Parking Apron 3		
	12" Portland cement concrete	1951	
	12" Base	1951	
	12" Base (compacted native material)	1951	
10	Parking Apron 4		
	12" Portland cement concrete	1952	
	12" Base	1952	
	12" Subbase (compacted native material)	1952	
10A	Parking Apron 4		
	12" Portland cement concrete	1944	
	4" Crusher run base "A"	1944	
	6" Crusher run base "B"	1944	
	4" Plant mix	1944	
11	Parking Apron 5		
	12" Portland cement concrete	1951	
	12" Base	1951	
	12" Subbase (compacted native material)	1951	
11A	Parking Apron 5		
	8" Portland cement concrete	1944	
	12" Base crusher run	1944	
11B	Parking Apron 5		
	12" Portland cement concrete	1944	
	4" Crusher run base "A"	1944	
	6" Crusher run base "B"	1944	
11C	Parking Apron 5		
	12" Portland cement concrete	1951	
	12" Base	1951	
	12" Compacted native material	1951	

Item No.	Section From Surface to Subgrade	Date Constructed	Date Strengthened or Sealed
12	Parking Apron 6		
	10" Portland cement concrete	1953	
	8" Base	1953	
	6" Compacted native material	1953	
13	Parking Apron 7		
	10" Portland cement concrete	1965	
	6" Base	1965	
	6" Subbase (compacted native material)	1965	
	Shoulders (50'):		
	2" Asphaltic concrete	1968	
14	Fueling lanes 3 to 8		
	10" Portland cement concrete	1959	
	8" Base	1959	
	6" Subbase (compacted native material)	1959	
15	Circular Fueling Lanes		
	10" Portland cement concrete	1970	
	6" Base	1970	
15A	Circular Fueling Hub		
	6" Portland cement concrete	1970	
	6" Base	1970	
16	Parking Apron (under construction at time of condition survey		
	Portland cement concrete	1975	
	Cement treated base course	1975	



APPENDIX A. FIGURE A-1

Appendix B

CLIMATOLOGICAL DATA

Temperature Data
(Degrees Fahrenheit)

	Means			Extremes			
Month	Daily Maximum	Daily Minimum	Monthly	Record Highest	Year	Record Lowest	Year
#	18	18	18	18		18	
January	64.1	44.9	54.8	87	1965	30	1952
February	65.1	46.2	56.0	93	1962	34	1965+
March	65.2	47.9	56.8	87	1964	33	1966
April	67.4	51.1	59.5	95	1966+	39	1953
May	69.7	54.3	62.2	96	1956	42	1967
June	72.8	57.3	65.3	100	1957	46	1967
July	78.8	61.3	70.3	101	1957	52	1952
August	80.4	63.0	71.9	97	1967+	53	1952+
September	79.8	61.0	70.7	111	1963	49	1954+
October	77.0	57.0	67.2	105	1961	46	1952
November	71.4	51.6	61.8	100	1966	38	1958
December	67.3	47.1	57.5	98	1963+	33	1960

Length of weather record in years.

+ Also occured on earlier day, month, or year.

Weather data source: Naval Weather Service Command, "Local Climatological Data for Selected U.S. Navy and Marine Corps Stations," June, 1968

Precipitation Data
(Inches)

Month	Mean	Maximum Monthly	Year	Minimum Monthly	Year	Maximum in 24 hrs.	Year
#	18	18		18		18	
January	2.25	6.48	1957	0.31	1965	1.75	1952
February	1.34	3.69	1959	T	1967	1.60	1958
March	1.55	5.40	1954	T	1959	1.37	1954
April	1.16	3.84	1965	T	1966+	1.41	1965
May	0.34	1.55	1957	T	1966+	1.05	1950
June	0.08	0.40	1957	T	1959+	0.37	1957
July	0.03	0.17	1954	0.00	1964+	0.12	1951
August	0.04	0.65	1951	0.00	1962	0.58	1951
September	0.19	2.10	1963	0.00	1956	1.04	1963
October	0.32	1.63	1957	0.00	1967	1.34	1951
November	1.22	5.66	1965	0.00	1956	2.03	1965
December	1.32	4.95	1951	0.05	1956	2.27	1951

Length of weather record in years.

+ Also occured on earlier day, month, or year.

Weather data source: Naval Weather Service Command, "Local Climatological Data for Selected U.S. Navy and Marine Corps Stations," June, 1968

Wind Data

Month	Mean Speed (Kts)	Prevailing Direction	Peak Gust		
			Speed (Kts)	Direction	Year
#	18		18		
January	4.4	E	39	W	1951
February	4.5	E	38	W	1960
March	4.6	E	37	WSW	1958+
April	4.7	WNW	41	WSW	1958
May	4.7	W	31	ENE	1956+
June	4.3	W	22	SSW	1951
July	3.8	WNW	21	NNE	1960+
August	3.8	WNW	88	NE	1950
September	3.8	NW	41	NE	1959
October	3.8	WNW	33	E	1967
November	4.1	E	38	W	1958+
December	4.1	E	38	WSW	1949

Length of weather record in years

+ Also occurred on earlier day, month, or year

Weather data source: Naval Weather Service Command, "Local Climatological Data for Selected U.S. Navy and Marine Corps Stations", June, 1968

Appendix C

CONDITION SURVEY PROCEDURES

Appendix C

CONDITION SURVEY PROCEDURES

Step 1. Prelminary Survey

In the prelminary survey the evaluators make a general and personal inspection of all airfield pavement areas, during which they note the type and distribution of defects in each facility (runway, taxiway, etc.). In addition, a previously-prepared construction history is consulted and areas of different construction and different pavement type (AC or PCC) within a facility are noted. As a result of these efforts, each pavement facility is then divided into "discrete areas" of reasonably similar failure modes for performance of the subsequent sampling and tally or measurement of defects. Thus, if the type and/or number of defects found in one portion of a facility are distinctly different from those found in another portion of that facility, discrete areas are selected on this basis. If, however, the pavement facility contains few defects of if the defects found are similar in type and distribution throughout the facility, each facility is individually divided for survey according to the construction history. Under either criterion, a discrete area may vary, for example, from a 500 foot length of runway or taxiway to the entire length of the facility. All discrete areas are numbered with a system that relates the discrete area to the runway, taxiway, etc., of which it is a part. For example, discrete areas comprising Runway 11-29 are designated R 11-1 and R 11-2, etc.; discrete areas for Taxiway 2 are T 2-1 and T 2-2, etc.

A special survey of singular occurrences of serious defects is made during the preliminary survey. This is necessary because the statistical sampling techniques utilized in the subsequent survey are effective in spotting defects only when such defects are numerous and/or relatively well distributed. This abbreviated special survey provides information on those infrequent defects, if any, which may present a problem to safe aircraft operation.

Step 2. Statistical Sampling and Defect Survey

After discrete areas are selected, a number of small "sample areas" are chosen within each discrete area. The total number of sample areas is determined by statistical theory as a function of the relative size of the discrete area. Actual locations of the sample areas are selected at random from the discrete area.

Sample areas in PCC pavements basically consist of individual slabs, usually 12½ x 15 feet in size. For the convenience of the evaluators, either a single slab or a number of adjacent slabs can be considered as a sample area. Both types of sampling area are shown schematically in Figure C-1. Note from Figure C-1 that individual sample slabs and/or sample strips are selected within the center 100 feet (laterally) of runways and within the center 50 feet (laterally) of taxiways by a random selection process. For parking aprons, mats, etc., similar sample areas are selected at random over the entire pavement area.

For AC pavements, sample areas are fifty-foot-square areas located as shown in Figure C-2. For parking aprons, mats, etc. (not shown in Figure C-2) sample areas are fifty-feet square, as for other traffic areas, and randomly located over the entire pavement area.

All defects or defected slabs in each of the selected sample areas are noted on appropriate data sheets. For PCC pavement slabs or sample strips, either single or multiple occurrences of a given defect type within the slab qualify the slab as a defected slab. For example, one or more spalls qualifies a slab as a spalled slab. A crack in the same slab requires that it be counted again, this time as a cracked slab. No measurement of length, area, etc. is recorded for PCC pavement defects. When a sample slab strip is chosen for test, the above mentioned tally method (slab by slab) is still utilized.

The defects found in AC sample areas are measured and tallied, rather than merely tallied as are those for PCC pavements. Depending on the type of defect, the total length in feet (for cracks, etc.) or total area in square feet (for pattern cracking, raveling, etc.) is recorded.

The above survey of defects found in sample areas (in each discrete area) are shown in column (c) of the Discrete Area Defect Summary sheets, Figures C-3 and C-4. Separate summary sheets are provided for portland cement concrete (PCC) and asphaltic concrete (AC) pavements. Total defect counts for the entire discrete area are calculated by a linear extrapolation of the defect data in column (c), and are shown in column (d) of the Discrete Area Defect Summary sheets. To remove the influence of the size of the discrete area on the total defect count (i.e., the bigger the area, the larger the defect count), the total defect count is divided by either the number of slabs in the discrete area (for PCC pavements) or by the area (in 10-square-foot increments) of the discrete area (for AC pavements). This gives a defect <u>density</u> (per slab or per 10 square feet) which is listed in column (e).

<u>Step 3. Defect Severity Weighting System</u>

A weighting system, providing a numerical weight for each type defect in proportion to the relative severity of that defect, is applied in the following manner to each of the defect counts in the discrete area;

given defect density x $\begin{matrix}\text{weight for that} \\ \text{type defect}\end{matrix}$ = $\begin{matrix}\text{weighted defect} \\ \text{density}\end{matrix}$

This is accomplished in columns (f) and (g) of the discrete Area Defect Summary sheets. Next, a total weighted defect density is obtained for each discrete area by summing column (g) of these sheets. Note that a letter suffix is added to each total weighted defect density for the purpose of further distinguishing between asphaltic concrete defect densities (suffix "A") and portland cement concrete defect densities (suffix "C").

The defect weighting guide developed by NCEL assigns greater weights to defects that (1) presently affect the safe operation of aircraft or the cost of aircraft operation; (2) will lead to increased airfield pavement maintenance costs; or (3) will result in significant deterioration of load-carrying capacity of the pavements. The resultant numerical weights are further modified to reflect variations in pavement environment from station to station. For example, higher (more severe) weights are assigned to defects which are affected by factors such as freezing weather, heavy rainfall, or blow sand for surveys of airfields located in areas where these undesirable environmental effects occur. Thus, it can be seen that the higher the numerical weighted defect density, the poorer the condition of the surveyed pavement.

Remarks concerning the general pavement condition and the defects identified are given in narrative form on each Discrete Area Summary sheet. In addition, photographs of typical pavement conditions noted during the survey are used to further illustrate typical pavement defects.

Step 4. Facility Summary--Weighted Defect Densities

A final step in providing a numerical condition rating for each facility (runway, taxiway, etc.) is accomplished in the Facility Defect Summary sheets, Figures C-5 and C-6. Again note that separate sheets have been provided for AC and PCC pavements. In these sheets the individual weighted defect densities for all discrete areas comprising the entire AC or PCC portion of a facility (runway, taxiway, etc.) are summarized in column (a). When an AC or PCC facility (or portion) has been divided into more than one discrete area for the condition survey, the proportional contribution of each discrete area to the entire AC or PCC facility area is determined in column (b). In column (c) these proportions are applied to the individual discrete area weighted defect densities listed in column (a) and added to obtain an overall average weighted defect density for the entire AC or PCC portion of the facility (marked "total" in column (c)). When an entire AC or PCC facility (or portion) has been designated a single discrete area (as often occurs), the proportionality factor in column (b) is obviously 1.00 and the discrete area weighted defect density from column (a) becomes the average weighted defect density for the entire facility (or portion) in column (c).

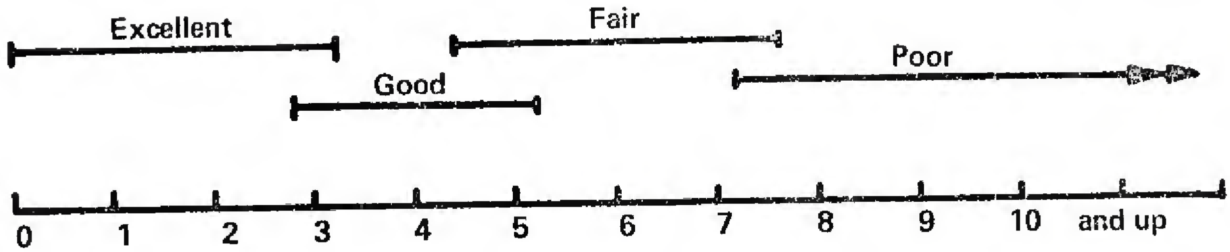
GENERAL COMMENTS ON CONDITION SURVEY PROGRAM

The weighted defect densities, listed in column (a) of the Facility Defect Summary for individual discrete pavement areas and in column (c) as averaged weighted defect densities for entire AC or PCC runways, taxiways, etc. (or portions thereof) represent, numerically, the surface condition of the airfield pavements at the station. As previously stated, the larger defect density numbers indicate basically a greater number and/or severity of defects per unit area of pavement, i.e., a poorer pavement. Thus, they represent the final product of the pavement condition survey. It should be noted specifically, however, that AC and PCC pavement defect densities, although often numerically similar, are obtained by two different condition survey techniques and, as such, are not numerically compatible and must not be combined. (It is largely because of this fact that the letter suffixes "A" and "C" have been affixed to defect densities for AC and PCC pavements respectively.) As an example, consider the common case of an AC runway with PCC ends. The condition survey system presented herein provides individual discrete are weighted defect densities for discrete areas selected on both AC and PCC pavements, but provides a separate average weighted defect density for the entire AC portion and a separate average weighted defect density for the combined PCC end pavements. It is not possible to combine these defect densities to obtain an averaged AC/PCC defect density for the entire runway. Thus the defect densities for AC and PCC are reported separately, given different letter suffixes, and should include the letter suffix when reference is made to them.

Individual numerical defect densities, however accurately they indicate pavement condition, may mean little to the reader of an individual airfield condition survey report, for he has no basis upon which to judge the relative severity of pavement condition associated with the numbers obtained for his pavements. The primary value of a numerical condition survey program will be the accumulation of uniformly-obtained, comparative condition data for many airfields which can best be correlated, studied, and used in the decision-making processes at headquarters levels.

For the benefit of the individual reader, however, an effort was made during the first year of pavement condition surveys (FY-70) to relate the numerical condition (defect densities) to the basic subjective condition descriptors (excellent, good, fair, poor, etc.) used in all previous Navy pavement evaluation procedures. Although the subjective condition-descriptor approach is poorly regarded as a means of comparing pavement condition from one airfield to another, the following diagram may serve temporarily as a rudimentary bridge between the old subjective system and the new (numerical) condition approach:

(old condition descriptors)



Weighted Defect Density

The system of numerical defect densities was developed to aid in determining the suitability of airfield pavement surfaces for satisfying aircraft operational requirements and to establish an unbiased, uniform basis for initiating maintenance and repair efforts. As such, defect densities are simply visually-determined indicators of the condition of the pavement and do not represent true "condition ratings" in that they do not include factors relating to pavement strengths, traffic usage, etc. It is possible that additional measurements or modifications may be considered necessary or desirable in future condition survey programs.

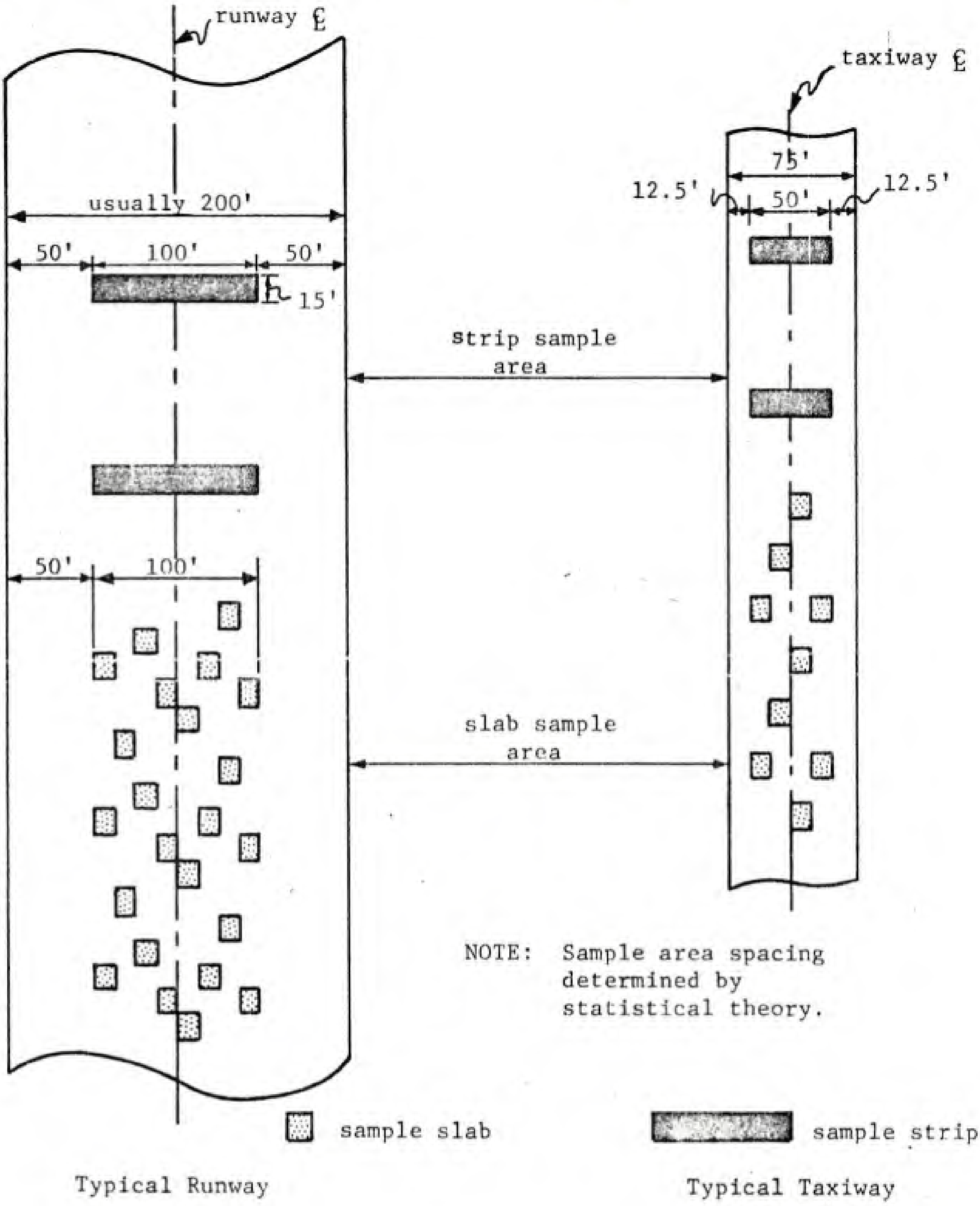


Figure C-1 Portland cement concrete sample areas.

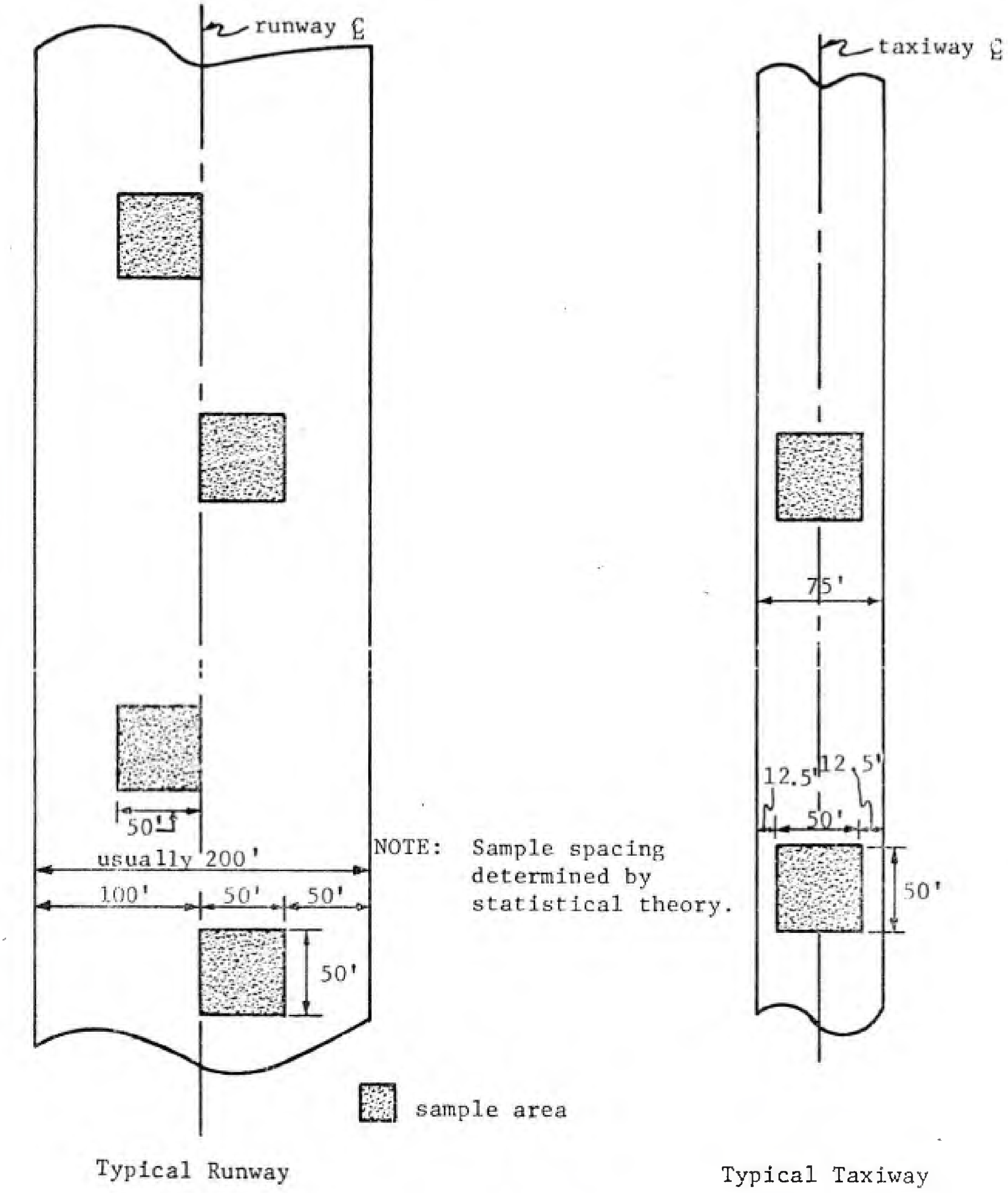


Figure C-2 Asphaltic concrete sample areas.

ASPHALTIC CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield E X A M P L E Facility Taxiway 2

Discrete Area T2-1 Area of Discrete Area (a) 97,700 ft²

No. of Sample Areas (b) 10 Ratio: (a/2500b) 3.9

Defect Type	Length or Area of Sampled Defects	Total Length or Area of All Defects: (c) x Ratio	Defect Density (per 10 sq. ft.) 10 d/a	Defect Severity Weight	Weighted Defect Density: (e) x (f)
	(c)	(d)	(e)	(f)	(g)
T.C., L.C. or LCJ*	80 ft	312 ft	0.0319	2.5	0.0798
Reflection Crack					
Faulting					
Patching					
Settlement or Depression	530 ft^2	2,067 ft^2	0.2116	9.0	1.9041
Pattern Cracking	126 ft^2	491.4 ft^2	0.0503	2.5	0.1257
Rutting					
Raveling					
Erosion—Jet Blast					
Oil Spillage					
Broken-up Area					
				Total	2.11 A**

Remarks on Pavement Condition

The depressions were generally 1/2" deep. Pattern cracking formed 6" to 12" polygons and was associated with the depressions. Longitudinal cracks were unsealed and 1/8" wide. (See Figure 5.)

* Transverse crack, longitudinal crack, and longitudinal construction joint

** Letter suffix "A" indicates asphaltic concrete pavement

Figure C-3. Typical Asphaltic Concrete Discrete Area Defect Summary

PORTLAND CEMENT CONCRETE DISCRETE AREA DEFECT SUMMARY

Airfield E X A M P L E Facility Taxiway 2

Discrete Area T2-2 Total Slabs in Discrete Area (a) 1,542

No. of Slabs Sampled (b) 193 Ratio a/b = 8.0

Defect Type	No. of Sample Slabs w/Defect	Total Slabs w/Defect: c x a/b	Defect Density (per slab) d/a	Defect Severity Weight	Weighted Defect Density e x f
	(c)	(d)	(e)	(f)	(g)
Faulting					
Corner Break	1	8	0.0052	2.5	0.013
L.C. or T.C. *	19	152	0.0985	1.0	0.098
I.C. **	1	8	0.0052	2.5	0.013
Depression		2***	0.0013	9.0	0.012
Spalling	59	472	0.3060	7.5	2.295
Scaling					
Disintegrated Slab					
Joint Seal	10	80	0.0518	2.5	0.130
Pumping					
				Total	2.57 C****

Remarks on Pavement Condition

Spalls were generally 1" wide by 3" long with some spalls up to 4" wide and 12" long. The longitudinal cracks found were mostly sealed. The depressions noted as singular defects consisted of two depressed and cracked slabs. The depression was approximately 1/2" deep. An attempt had been made to repair these slabs with portland cement concrete. Joint seal was missing in strips 4" to 12" long. (See Figures 25 and 26.)

* Longitudinal crack or transverse crack
** Intersecting crack
*** Counted as singular defects during the preliminary survey
**** Letter suffix "C" indicates portland cement concrete pavement

Figure C-4. Typical Portland Cement Concrete Discrete Area Defect Summary

ASPHALTIC CONCRETE FACILITY DEFECT SUMMARY

Airfield E X A M P L E

Date Surveyed

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Taxiway 2 T2-1	2.11 A	1.00	2.11 A
Taxiway 10 T10-2	0.004 A	1.00	0.004 A
Towway 1 TOW-1	3.77 A	1.00	3.77 A
Parking Apron 2 PA2-1	7.29 A	1.00	7.29 A
Parking Apron 6 PA6-1	7.44 A	1.00	7.44 A
Parking Apron 7 PA7-1 PA7-2	 4.97 A 23.18 A	 0.79 0.21	 3.93 4.87 8.80 A (Total)
Parking Apron 8 PA8-1	2.76 A	1.00	2.76 A
Central Mat CM-1	2.89 A	1.00	2.89 A

* If facility entirely constructed of AC, indicates total facility area. If facility only partly constructed of AC, indicates total area of AC portion of facility.

** Letter suffix "A" on weighted defect densities indicates asphaltic concrete pavements.

Figure C-5. Typical Asphaltic Concrete Facility Defect Summary

PORTLAND CEMENT CONCRETE FACILITY DEFECT SUMMARY

Airfield E X A M P L E

Date Surveyed

Facility (or portion)	Weighted Defect Density Total	Ratio: Discrete Area / Total Facility Area*	Average Weighted Defect Density (a) x (b)
	(a)**	(b)	(c)**
Runway 11-29			
R11-1	0.80 C	0.25	0.02
R11-2	4.43 C	0.75	3.33
			3.35 C (Total)
Runway 18-36			
R18-1	1.25 C	0.68	0.85
R18-2	0.76 C	0.32	0.28
			1.13 C (Total)
Taxiway 1			
T1-1	2.82 C	0.12	0.34
T1-2	0.98 C	0.88	0.86
			1.20 C (Total)
Taxiway 2			
T2-2	2.57 C	1.00	2.57 C
Taxiway 3			
T3-1	1.82 C	1.00	1.82 C
Taxiway 4			
T4-1	3.02 C	1.00	3.02 C
Taxiway 5			
T5-1	0.98 C	1.00	0.98 C
Taxiway 6 and Taxiway 7			
T6-1 and T7-1	0.06 C	1.00	0.06 C

* If facility entirely constructed of PCC, indicates total facility area. If facility only partly constructed of PCC, indicates total area of PCC portion of facility.

** Letter suffix "C" on weighted defect densities indicates Portland cement concrete pavements.

Figure C-6. Typical Portland Cement Concrete Facility Defect Summary

Appendix D.

Mu-Meter Test Results

Appendix D. Mu-Meter Test Results
USNAS Miramar, California

Test Location Run #	Runway Heading	Average Time After Wetting Min.	Average Coefficient of Friction (Mu)	Maximum Coefficient of Friction (Mu)	Minimum Coefficient of Friction (Mu)
Runway 6L-24R					
Test Section A					
1	24	0.94	0.38	0.64	0.02
2	6	1.91	0.40	0.75	0.03
3	24	3.71	0.46	0.76	0.03
4	6	5.18	0.54	0.77	0.08
5	24	5.74	0.57	0.79	0.12
6	6	11.58	0.65	0.82	0.12
7	24	15.34	0.69	0.84	0.09
8	6	19.88	0.71	0.81	0.20
Test Section B					
1	24	0.92	0.51	0.64	0.27
2	6	1.73	0.57	0.79	0.18
3	24	3.44	0.67	0.76	0.33
4	6	5.06	0.73	0.81	0.32
5	24	6.45	0.76	0.81	0.43
6	6	9.77	0.78	0.84	0.50
7	24	20.55	0.77	0.79	0.64
Test Section C (2000 ft)					
1	24	2.25	0.50	0.68	0.14
2	6	3.62	0.58	0.71	0.30
3	24	5.43	0.63	0.75	0.38
4	6	6.80	0.67	0.75	0.37
5	24	9.33	0.71	0.77	0.48
6	6	14.47	0.74	0.80	0.48
7	24	19.93	0.73	0.77	0.54
Test Section D					
1	6	1.06	0.62	0.70	0.50
2	24	2.24	0.64	0.72	0.51
3	6	3.92	0.72	0.77	0.62
4	24	4.93	0.73	0.79	0.62
5	6	6.86	0.78	0.80	0.70
6	24	15.18	0.76	0.80	0.70

Mu-Meter Test Results
USNAS Miramar, California (Continued)

Test Location Run #	Runway Heading	Average Time After Wetting (Min.)	Average Coefficient of Friction (Mu)	Maximum Coefficient of Friction (Mu)	Minimum Coefficient of Friction (Mu)
Runway 6R-24L					
Test Section A (2000 ft)					
1	6	1.62	0.78	0.84	0.58
2	24	2.74	0.76	0.80	0.51
3	6	4.44	0.80	0.85	0.56
4	24	5.63	0.79	0.84	0.54
5	6	8.64	0.79	0.84	0.55
6	24	11.78	0.79	0.84	0.57
7	6	17.67	0.78	0.82	0.63
8	24	23.15	0.76	0.80	0.64
Test Section B (2000 ft)					
1	24	1.64	0.70	0.73	0.59
2	6	3.02	0.69	0.71	0.64
3	24	4.70	0.69	0.72	0.64
4	6	5.92	0.68	0.71	0.64
5	24	9.81	0.67	0.71	0.63
6	6	15.88	0.66	0.69	0.62
Test Section C					
1 (AC)	24	0.95	0.64	0.68	0.52
(PCC)			0.48	0.58	0.21
2 (AC)	6	1.82	0.65	0.68	0.50
(PCC)			0.52	0.64	0.22
3 (AC)	24	3.28	0.68	0.72	0.45
(PCC)			0.58	0.70	0.28
4 (AC)	6	4.16	0.69	0.73	0.56
(PCC)			0.61	0.71	0.32
5 (AC)	24	5.88	0.69	0.72	0.46
(PCC)			0.65	0.74	0.36
6 (AC)	6	6.78	0.68	0.72	0.58
(PCC)			0.66	0.72	0.38
7 (AC)	24	11.18	0.68	0.70	0.52
(PCC)			0.72	0.76	0.56
8 (AC)	6	22.53	0.66	0.68	0.48
(PCC)			0.72	0.75	0.48
9 (AC)	24	26.91	0.65	0.68	0.50
(PCC)			0.76	0.79	0.58